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# THE MECHANISM OF HEREDITY AS INDICATED BY THE INHERITANCE OF LINKED CHARACTERS

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IT is generally recognized to-day that the central idea of Mendel's discovery in regard to heredity is that when two contrasting elements enter a hybrid, one from each parent, they separate in the germ-cells of the hybrid, so that the germ-cells are *pure* like those of the original parents in regard to each element.[1] Chance meetings of the germ-cells give the ratios that are characteristic of Mendelian heredity. This is illustrated by the example that Mendel gave.

When a pea having green seeds is crossed with a pea having yellow seeds a hybrid pea is produced. When the germ-cells of the hybrid are ripened, each ovule carries either the element for green or that for yellow, but never both. Yellow and green have separated. The same separation occurs in the formation of the pollen. If self-fertilization now takes place chance combinations of the yellow- or green-bearing ovules with the yellow- or green-bearing pollen give one pure yellow pea, two hybrid (yellow) peas, one pure green pea, as shown in Fig. 1.

Mendel discovered that the same principle holds when two pairs of

[1] Mendel speaks of *characters* as forming pairs. To-day we speak of factors or genes as the paired elements (allelomorphs) in the germ-cells, and these are supposed to act as differentials in producing the characters in the adult animal or plant. The English school considers the presence of a factor as one allelomorph and its absence as the contrasting factor. For instance, if yellow color is due to a present factor then if it were lost the color that results is green. But since we know nothing about the material in the germ-plasm that by interacting with other parts gives yellow in one case and green in the other, it seems to me gratuitous to postulate the nature of the change in the germ plasma. It is only necessary to assume that the original factor and a new factor form a pair without in any way committing one's self as to how these two allelomorphic factors are related to each other.

characters are involved. If one of the original parents had round seeds and the other wrinkled seeds, these characters separate independently of the green-yellow separation. We say technically that the pair yellow and green, and the pair round and wrinkled segregate independently of each other. Chance combinations of the germ-cells in a double hybrid of this sort give nine yellow round peas, three yellow wrinkled peas, three green round peas and one green wrinkled pea (Fig. 2).

The same rule applies to three or more pairs of characters. Mendel assumed in fact that independent assortment[2] always takes place no matter how many characters are involved.

In more recent times evidence has been accumulating which shows that the chromosomes are the bearers of most of the elements (factors) that produce those characters that we study in heredity. I can not take up the work that seems to me to place this hypothesis on a very probable basis, but I shall simply assume that it is a reasonable conclusion from the evidence at hand.

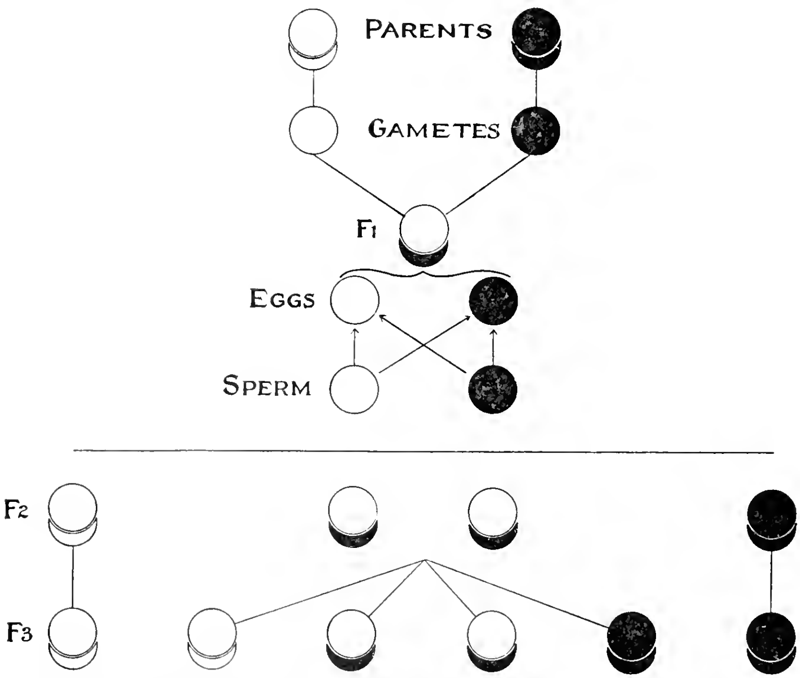


FIG. 1. Diagram to illustrate Mendel's law of segregation. Individuals (zygotes) are represented by superimposed circles, whose colors stand for the factors involved. Gametes (germ-cells) are represented by single circles.

[2] The term segregation applies strictly to the process of separation of the contrasted factors (allelomorphs). When more than one pair is involved, the distribution that follows the segregation of each pair is called assortment in the text, and assortment is a different process from segregation; although it is the resultant of segregation so far as each pair is concerned.

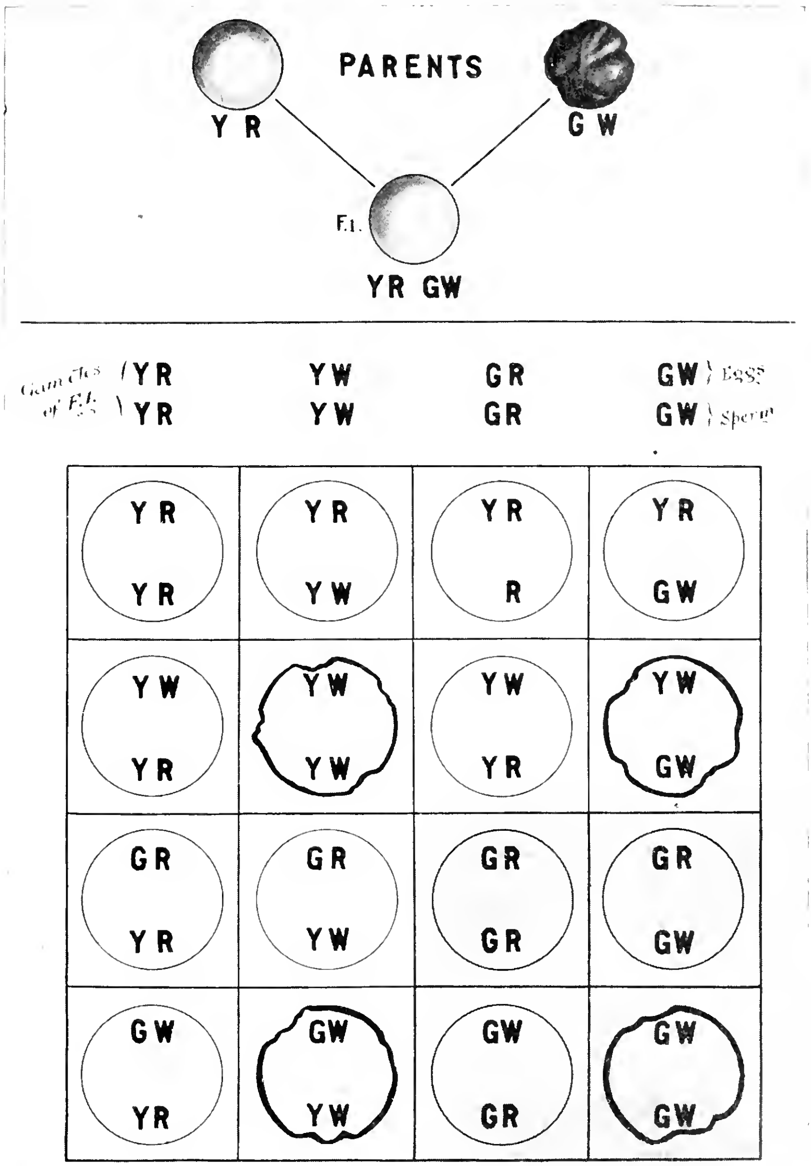


FIG. 2. Diagram to illustrate inheritance of two pairs of Mendelian characters, viz., yellow-green and round-wrinkled peas. The 16 small squares represent the composition of the 16 $F_2$ peas; viz., 9 YR, 3 YW, 3 GR, 1 GW.

In each animal or plant there are in general two of each kind of chromosomes.[3] One of each kind has come from the father, one from the mother, at the time of fertilization (Fig. 3, *a*). A hybrid likewise

[3] Except in those cases where the male has one less chromosome than the female. In such cases the single sex chromosome of the male has no mate.

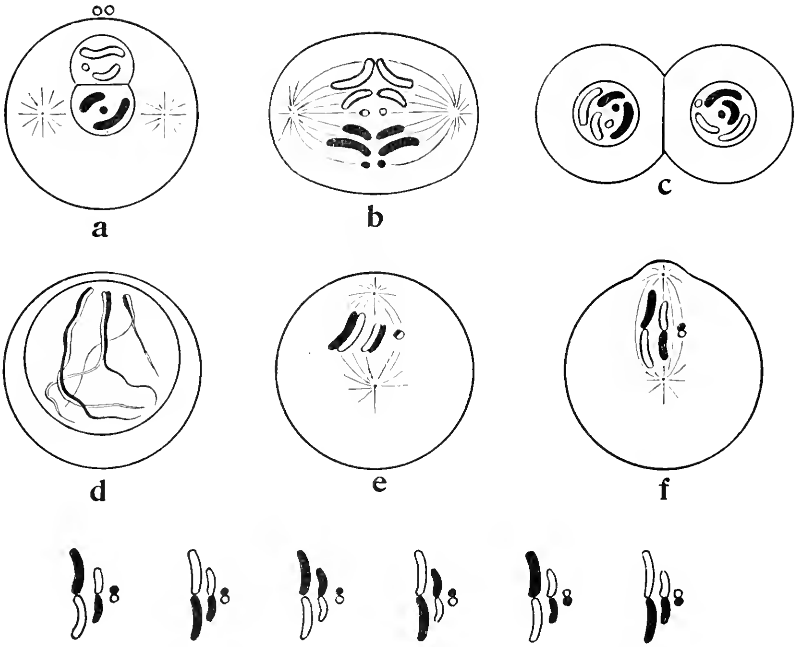


FIG. 3. Diagram to show the pairs of chromosomes (*a*, *c*) and their behavior at the time of maturation of the egg. Three pairs of chromosomes are represented; three from one parent, three from the other. The six possible modes of separation of these three are shown in the lowest line.

gets one of each kind of chromosome from one parent and one of each kind from the other parent. At the maturation of the germ-cells the maternal chromosomes and the paternal chromosomes come together in pairs and appear to fuse (Fig. 3, *d*, *e*). They then separate, and after two peculiar divisions one chromosome of each pair goes into the egg and one into the polar body. Similarly for the sperm. There is no evidence that all the maternal chromosomes go to one germ-cell, and all the paternal to the other, more frequently than chance assortment calls for, and we are free to suppose that a *random assortment* of chromosomes takes place, so that each egg and each sperm gets one of each kind regardless of its parental origin (Fig. 3, lower line).

With the acceptation of this view it appears at first sight that in a given race there can not be more independent pairs of characters that show assortment than there are pairs of chromosomes. Since the number of chromosomes is fairly limited it might appear that we could reasonably expect to make still more probable the chromosome hypothesis by finding that the number of independent pairs of Mendelian characters is not greater than the known number of chromosomes in a given race; or else we might expect to disprove the chromosome hypothesis by showing that the number of independent pairs of characters does transcend the number of the chromosomes. As a matter of fact, several strains are known in which the number of Mendelian characters is greater than the number of chromosomes; but just here a remarkable phenomenon has come to light that shows in certain cases that many of the characters do not segregate independently, but are linked to each other as though they belonged to some common system. As a result, peculiar ratios appear, that differ from the expected Mendelian ratios in so far as that expectation rests on independent assortment. The question here raised has, therefore, taken on a new aspect, and it has become essential to discover whether there are as many, or more, or fewer groups of linked characters than there are kinds of chromosomes.

Correns appears to have been the first to call attention to a case in which peculiar ratios appeared which he attributed to coupling. Bateson and his coworkers have described several instances of the same kind. They have found that certain characters in sweet peas do not fulfill the expectation for independent assortment of different pairs of characters, although they do show Mendelian segregation when each pair is taken separately. This phenomenon has been described as coupling or repulsion.[4] I shall refer to it as linkage.

It was found, for instance, in sweet peas that when plants with blue flowers and long pollen grains were crossed to plants having red flowers and short pollen grains in the grandchildren, the blues had for the most part long pollen and the reds short pollen. Again when blue and red flowers with erect and hooded standards were used all the red grandchildren had erect standards.

We have met with these same phenomena at nearly every step in our studies of heredity in the fruit fly, *Drosophila.* Over one hundred mutants have appeared from many of which pure races have been formed. At present we have studied fifty-nine of these sufficiently to show that they fall into three great groups.

The characters in the first group show sex-linked inheritance. They follow the sex chromosomes. The second group is less extensive. Since the characters in this group are linked to each other we say that they lie in a second chromosome. The characters of the third group have not as yet been so fully studied, except to show that they are linked. We

[4] Bateson and Punnett formerly defined coupling as the association of two factors and repulsion ("spurious allelomorphism") as the condition where two factors are usually not associated in the same gamete. They point out that the same idea is expressed by saying that if two dominants come from one parent and two recessives from the other coupling is observed; but if one dominant and one recessive come from each parent, repulsion will be found. For the fly, *Drosophila,* we have pointed out (*Jour. Expt. Zool.,* 1911) how both these results can be accounted for on the hypothesis that the factors concerned are carried by the chromosomes. Bateson has more recently changed his conception of coupling and repulsion.

place them in the third chromosome without any pretensions as to which of the pairs of chromosomes are numbered II. and III.

The arrangement of these characters in groups is based on a general fact in regard to their behavior in heredity, viz., *A member of any group shows linkage with all other members of that group, but shows independent assortment with any member of any other group.* In *Drosophila ampelophila* there are five pairs of chromosomes. According to Stevens, the sex chromosomes are attached to one of the other pairs. Three of the five pairs are occupied according to our view by the three groups of linked factors that we have studied. There are as yet two more pairs of chromosomes than there are groups of linked factors.

On the chromosome hypothesis we can readily see that if the factors that stand for characters lie in the chromosomes, those that lie in the different chromosomes should give independent assortment, and the ratios obtained in breeding experiments should be the expected Mendelian ratios. On the other hand, it may appear that the factors that lie in the same chromosomes should always march together through successive generations. If this were true the linked characters would be absolutely linked to each other. Experience shows, however, that the linked characters are not absolutely linked, but that to a greater or a less degree, according to the factors involved, interchanges must in some way take place. Here fortunately there is a cytological relation that may be utilized to explain how interchanges between like chromosomes may take place.

It has been observed when the homologous pairs of chromosomes unite before maturation of the egg and sperm that they twist around each other. In consequence, parts of each chromosome may come to lie on one side of the twist and other parts on the other side. If at times the chromosomes break at the crossing point, and each then unites with that part of the other chromosome that lies on the same side, the new chromosomes that emerge later from the pair will be made up of parts of each chromosome to the extent to which breaking has taken place at some of the crossed levels.[5]

[5] The twisting of the chromosomes has been described by a number of writers. Janssens has observed that at the time when the pairs are about to separate, cross-bridges between the pairs (more strictly between the halves of the pairs) can be seen. Whether these cross-bridges are the result of the kind of crossing referred to in the text can not be discussed here. Janssens points out that the mechanism of interchange between homologous chromosomes, by means of the cross-bridges furnishes an interesting explanation of those cases where the number of distinct allelomorphic pairs of characters is greater than the pairs of distinct chromosomes. The evidence seems to me to indicate furthermore that independent assortment occurs when factors lie in different chromosomes, while the interchange between homologous chromosomes accounts only for the relatively small proportion of crossing-over. Only when the factors lie very far apart is there a numerical approach to the independent assortment of factors lying in different chromosomes.

In consequence the two new chromosomes are no longer made up of the same parts as the original chromosomes, but of pieces of both. If we think of all the factors that lie in one chromosome as linked because ordinarily they go together, in the sense that they are likely to remain in that chromosome, this linkage will be disturbed, or broken, at one time only in the history of the chromosomes, viz., at the time of conjugation of the pairs, when an interchange between the members of an homologous pair becomes possible.

Let me illustrate by means of two concrete cases, and by preference cases that belong to the sex chromosomes, because the conditions here are simpler and more convincing, and because we have more definite information concerning the mode of distribution of these chromosomes than of any other.

When a male fruit fly with yellow body color and white eyes is mated

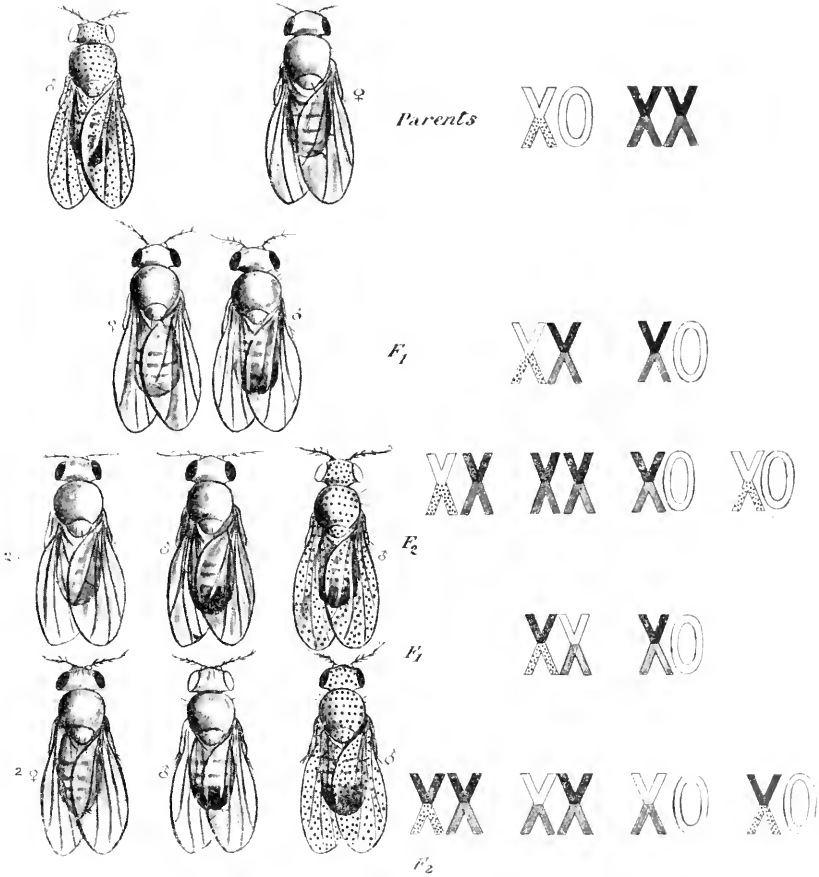


FIG. 4. Diagram illustrating the results of crossing a yellow (stippled), white-eyed male to a gray, red-eyed female of *Drosophila*. To the right the sex chromosomes are represented, colored in the same way as the flies.

to a gray (wild) female with red eyes, the daughters are gray with red eyes, and the sons also (Fig. 4). The explanation of this result is shown in the diagram in which the sex chromosomes are represented by X's which are marked like the characters they stand for. The daughter gets a "red-gray" chromosome from the mother and a "white-yellow" chromosome from the father. Since red and gray dominate the color is determined by these factors. The son gets his single sex chromosome from his mother which carries the factors for gray body color and red eyes.

When the hybrid ($F_1$) flies are inbred they produce one kind of female and four kinds of males as shown in the next figure. In order to understand how these classes arise let us follow the history of the sex chromosomes.

The $F_1$ female had two kinds of sex chromosomes, that we may call briefly WX and RX. Either may pass out into the polar body leaving the other chromosome in the egg. Consequently there are two kinds of eggs. The $F_1$ male has only one sex chromosome GRX which goes into the female-producing spermatozoon. The other, the male-producing spermatozoon, does not carry an X chromosome. When the female-producing sperm fertilizes either kind of egg it brings in the two dominant factors GR; hence all the females are gray in body color and have red eyes. Since the male-producing sperm does not bring into the egg

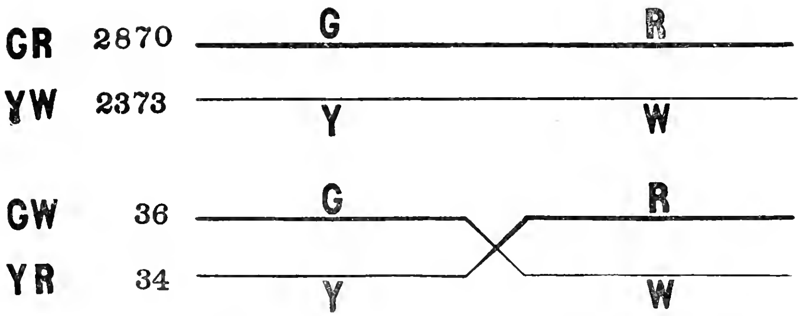


FIG. 5. The two upper lines represent the two sex chromosomes of the female, showing their original composition, viz., GR and YW. The lower line shows "crossing-over" between the two pairs. The numerals to the left give the $F_2$ males, whose composition is the same as that of the chromosome that stands next to them. The males receive one or the other of these chromosomes from their mother.

any X chromosome, the sex-linked factors in that egg are those of the egg itself. Since without interchange between the sex chromosomes there are two kinds of eggs there will be two kinds of males, namely, gray-white and yellow-red.

But the experiment shows that there are *four kinds* of males. Their origin can be explained if we assume that in some of the eggs the sex chromosomes prior to the extrusion of the polar bodies have crossed, and the parts have reunited at some point between the factors in question. This is shown in the next diagram (Fig. 5) where the crossing over is represented. The number of times that this occurs will be measured by the number of the two other classes of males, the gray-red and the yellow-white. The actual results are:

| GR♀ | GR♂ | GW♂ | YR♂ | YW♂ |
|---|---|---|---|---|
| 6080 | 2870 | 36 | 34 | 2373 |

Expressed in percentages the crossing over takes place in 1.3 per cent. of the total number of males produced.

The hypothesis of independent assortment for two pairs of characters calls for equal numbers in each of the four classes of males in the cross just given. The numbers show how far the actual results depart from this expectation.

There is one further point here that demands consideration. If the factors lie in a linear order in the chromosome as the hypothesis requires it is evident that the nearer together two factors lie the smaller will be the chance that a twist occurs between them. Consequently the frequency of crossing over can be taken as a measure of the distance of the factors from each other in the chromosome. On this basis the position of these factors in the chromosomes has been calculated. I shall return to this point later.

When three pairs of sex-linked characters are involved the result is essentially the same, but the possibility of another class of individuals, viz., those produced by double crossing over offers certain relations of peculiar interest. If a female fly with the characters yellow body color, white eyes and miniature wings is mated to a wild male with gray body color, red eyes, and long wings the daughters are like the father and the

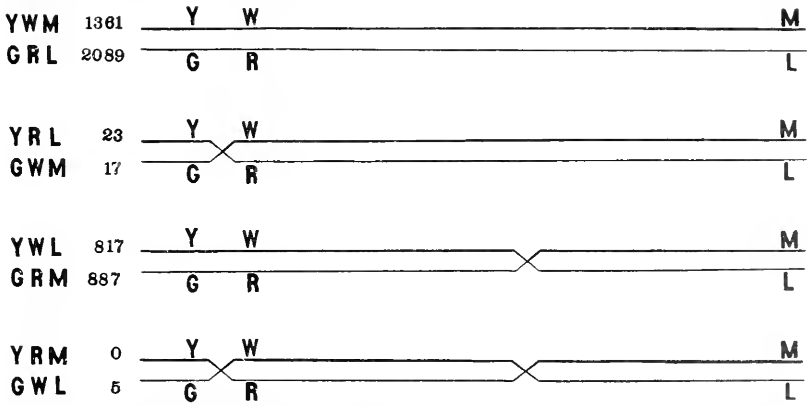


FIG. 6. Diagram illustrating the two sex chromosomes in the $F_1$ female derived from a YWM female and a GRL male. The first (upper) pair of lines show the chromosomes without crossing over. To the left the number of the $F_2$ flies of the composition of the two chromosomes respectively are represented. The second pair of lines illustrate the results of "single crossing-over" between YW and GR. The third pair of lines represent the "single crossing-over" between WM and RL. The fourth pair of lines represent the results of "double crossing-over."

sons are like the mother. The explanation is here the same as in the last case. These inbred give the following significant classes:

| GRL | YWM | GWM | YRL | GRM | YWL | GWL | YRM |
|---|---|---|---|---|---|---|---|
| 1483 | 1265 | 16 | 16 | 720 | 684 | 4 | 0 |

The diagram, Fig. 6, shows the imagined relation of the chromosomes to each other. There are two classes, YWM, GRL, representing "non-crossing-over." There are four classes, YRL, GWM, YWL, GRM, where "single crossing-over" is expected. There are also two classes, YRM, GWL, representing "double crossing-over."

Other experiments show that the factor for miniature gives a high percentage (about 34) of cross-overs with yellow or with white. We place it at a correspondingly distant point which means that the likelihood of a twist occurring between the loci for miniature and that for yellow (or for white) is large. Other experiments show that the factor for yellow body color and that for white eyes rarely cross over. We place them therefore near together. The chance that a twist should occur between Y and W and at the same time another twist between W and M is very small. It is to be anticipated that the double crossing-over would be rare, as it is, in fact.[6]

I have given the argument on which we base our scheme of the linear order of the factors in the chromosomes. I need hardly say that there is no pretension that the distances (calculated in per cent.) correspond to real distances, for we know nothing of the actual space occupied. But the numbers give the *relative* positions of the loci in the chromosomes. The procedure justifies itself in one all-important respect. By its means we can calculate results before they are tried, and experience shows that the prediction comes true. For example, if we know the location of a factor Y and of another factor W, then when a new factor, M, appears we need only determine its position in regard to Y and we can predict what will happen when a cross is made between M and W. In a word, we can by determining the position of a new factor in regard to any other known factor calculate the results for all other known factors in the same chromosome. When we recall the wide departure, due to linkage, from the accepted Mendelian ratios based on random assortment it is no small gain to be able to calculate the results of all possible combinations by determining two known points. I make this statement even though we may at any time find that linkage is influenced by the environment, or by characteristics peculiar to individuals or to pure strains. Nothing would be more harmful at this stage than that the situation be prejudiced by absolute statements.

If any one objects to locating these points in chromosomes and pre-

[6] The first and best description of double crossing over is to be found in Sturtevant's paper (*Jour. Expt. Zool.*, 1913).

fers to treat biological problems in terms of mathematics he can make the same predictions from the data that can be treated without regard to the mechanism of the chromosomes. But since we find in the chromosomes all the machinery actually at hand for carrying out this procedure, it seems to me reasonable to base our conceptions on this mechanism until another is forthcoming. And if it should prove true that we have found the actual mechanism in the organism that accounts for segregation, assortment and linkage of hereditary factors we have made a distinct advance in our study of the constitution of the germ plasm.

It has been pointed out to me, more than once, that the views here presented concerning the "architecture" of the chromosome are similar to the views (assumed to be discredited) that Weismann advanced several years ago. But it should not be overlooked that Weismann's purpose in locating his determinants in the chromosomes was only that he might separate them again during development. He tried, in fact, to explain development in this way without, however, explaining what determines during development the *orderly disintegration* of the chromosomes. Nothing of the sort is postulated, or implied, on my view. Weismann's hypothesis was purely speculative. My own conception of the constitution of the chromosomes rests on numerical data obtained from hereditary characters. All of the chromosomes are supposed to go intact to every cell of the body as observation, so far as it goes, shows to be the case. How differentiation takes place is a question quite remote from the idea of the architecture of the chromosomes in their relation to hereditary characters.

There is but one fundamental similarity between my own view and that of Weismann. The chromosomes, looked upon as the vehicles of heredity, are assumed by both of us to have definite structures and not to be simply bags filled with a homogeneous fluid. The discrete parts (factors) of these structures are supposed to influence the course of differentiation, but there the resemblance ends. A factor, as I conceive it, is some minute particle of the chromosome whose presence in the cell influences the physiological processes that go on in the cell. Such a factor is supposed to be one element only in producing characters of the body. All the rest of the cell or much of it (including the inherited cytoplasm) may take part in producing the characters. So far as such things as unit characters exist I look upon them merely as the most conspicuous result of the activity of some part of the chromosome. A single factor may affect all parts of the body visibly, or a factor may preponderantly influence only a limited section of the body. As a matter of fact, if we look carefully, we can generally find far-reaching effects of single factors. On the other hand, Weismann's idea of development emphasizes the intimate relation between his determinant and a specific character of the body. His writings often leave the impression that he supposes the determinants of the chromosomes to pass out into the cell, multiply there, and become the differentiated part. Perhaps this is only due to his attempt to visualize his conception, and he might grant that the differentiation of the determinants may depend on the interaction of many parts of the cell. But if we take his view literally to mean that the determinants are the materials out of which specific structures are directly built up, then his conception of the nature of a determinant is widely different from my own concerning the relation of "factors" and body characters.

# THE PRESENT STATUS OF CANCER RESEARCH

By Dr. LEO LOEB

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IT is well known that all organisms, plants as well as animals, are composed of small units—the so-called cells—in which a nucleus is surrounded by protoplasm and certain special structures. Each part of the animal body is formed by aggregations of different kinds of cells. The skin and the cavities within the body as well as the glands are composed of epithelial cells, the bones and muscles are produced by special bone and muscle cells. Uniting the various special structures and cell-layers in the body, we find the so-called connective tissue consisting of special cells (connective tissue cells) and their product, the connective tissue fibers.

In the normal adult organism some kinds of cells are entirely or almost at a standstill as far as their growth (increase in number and size of cells) is concerned, while other kinds of cells are continually propagating. However, as for each newly formed cell an old one is cast off, no actual increase in the number of cells takes place during adult life under normal conditions. If, however, a small part of the body, *e. g.*, the skin, is removed, the neighboring cells begin to proliferate, and soon fill out the defect. We call this kind of growth regenerative. Very energetic cell proliferation of course is necessary for the transformation of an ovum into the fully developed young organism. This growth, which ceases as soon as the definite organism has been formed and the various organs have been differentiated, we call embryonic growth. A very interesting rapid cell proliferation takes place also in the uterus after the insertion of the ovum, leading to the formation of the maternal placenta.

In the normal adult organism, a definite equilibrium exists between the different kinds of cell aggregations which we call tissues. Each kind of cell respects the territory of the neighboring cells. Not rarely it happens however that suddenly in a young or adult organism cells in a certain part of the body begin to proliferate in an unusual manner; they multiply more or less rapidly. This growth can not be called regenerative, because there was no primary defect to be filled out, and if there had been such a defect the proliferation does not limit itself to wound healing. This multiplication of cells leads to a definite swelling in a certain part of the body. We call it a tumor. The aggregation of newly formed cells may form a well-defined mass which simply pushes aside the neighboring parts of the body. After some time the growth may entirely cease or it proceeds usually slowly. In this case we speak of a "benign" tumor. In many other cases, however, the newly formed cells not only multiply, but they also invade the neighboring tissues either as isolated cells or in clusters of cells. Each cell which migrates in the neighboring territory becomes again the center for the formation of a new tumor inasmuch as it has the power for indefinite propagation. Other cells even invade the lymph or blood channels of the body, and are carried with the lymph or blood stream to different parts of the body. At certain places they can not pass the narrow passages, they remain attached to the vessel wall, begin again to multiply, to break through the vessel wall into the neighboring tissue and produce at various places, often distant from the original site of the tumor, secondary tumors which are called metastases. This infiltrating, metastatizing tumor we call a malignant growth or a cancer. According to the kind of cells which form the cancer and according to the proliferative and infiltrative energy of the cells composing the growth we distinguish many varieties of cancer. There are morphological as well as physiological differences between different varieties of cancer. Roughly we may however classify the various cancers in those derived from epithelial tissue (for instance of the skin, stomach, uterus, the various glands) which we call carcinomata and those derived from proliferating connective tissue cells. Connective tissue in any part of the body may give rise to cancer. These connective tissue cancers are called sarcoma. The growth of a cancer exerts injurious influences on the organism as a whole. Through pressure on neighboring organs it often interferes with important functions of the digestive, respiratory, excretory organs, and leads to serious disturbances of metabolism. It often breaks through the epithelial membranes of the skin or of the inner cavities of the body; under those conditions parts of the tumor die, break down, and are cast off; an ulcerative surface is thus produced which serves as a place where certain bacteria find a favorable culture medium; putrefaction takes place and the absorption of the putrid material further weakens the organism. But even without the formation of an ulcer, parts of the tumor which are under unfavorable conditions of nourishment constantly die (become "necrotic"), while neighboring parts continue to grow. The absorption of the necrotic material may also exert an unfavorable influence on the metabolism. It is furthermore very probable that the living tumor cells give off certain substances which differ quantitatively or qualitatively from the substances produced in the normal organism, but whether these latter substances exert a toxic influence on the organism it is impossible to state at the present time. Cancer almost invariably progresses continuously and it is doubtful whether it ever disappears spontaneously. It is therefore a disease which leads without special interference to the death of the patient, sometimes very soon, sometimes many years after the first symptoms appear, according to the rapidity of the growth of the cancer. The characteristic feature of cancer as a disease may therefore be stated as follows: Cancer consists in an abnormal multiplication of cells at a certain, at first, usually well-defined place of the body. All the deleterious results are primarily produced through this continuous growth which spreads into different parts of the body. This growth as such through the pressure it exerts on neighboring organs or through its infiltration into and destruction of vital parts of the body leads to the death of the affected individual, secondarily toxic influences may be added to the primary results of the growth; but these toxic influences are as far as we know not of a specific character. It is different in the so-called infectious diseases. There the disease consists primarily in an intoxication by products given off by the invading organisms and a proliferation of the body cells plays only a subordinate rôle in the disease process.

While we can thus, in a rough way, define and differentiate cancer from certain other diseases, we must be well aware of the fact that a complete and satisfactory definition of a process can be given only after the completion of its scientific analysis. Usually, however, definitions are given in the beginning of the study of a certain process; and they have therefore only a provisional value. Certain apparent, often superficial features are at first used for characterization. During the progress of scientific investigation new relationships to neighboring fields are discovered, differences which at first appeared to be of a qualitative are gradually to be found to be merely of a quantitative character. Thus we must prepare for the eventuality that the sharp differentiation between cancer and infectious or toxic diseases may not be upheld through future investigations. In fact already at the present time we know of conditions which seem to be intermediate between the two sets of phenomena and it is probable that we will gradually have to add certain subdivisions defining conditions which have factors in common both with cancer and the so-called infectious diseases. At present it is of comparatively little importance to discuss whether certain intermediate phenomena are to be classed as cancer or infectious disease, while it is of the greatest importance to describe and analyze the character of these intermediate phenomena. In a similar manner, it is of relatively slight importance to justify or deny the admissibility of calling certain processes in animals and plants cancer—the definition of cancer necessarily being a provisional one—while it is of the greatest importance to discover similarities between certain tumor-like conditions in man, animals and plants.

We have various methods for approaching the cancer problem. We can observe the frequency with which human cancer appears, its symptoms, and conditions which precede it. We can study the finer structure and mode of development of cancer with the microscope on pieces of tumor which have been excised. We can study cancer from a comparative point of view, its occurrence in animals and plants. The comparative study leads to the experimental investigation of cancer in animals.

## 1. Frequency, Distribution, Varieties of Human Cancer

Cancer among man is found in all countries where a closer search for it has been instituted. The frequency with which it occurs differs, however, very much among people living under the ordinary conditions of present civilization in Europe and America and among races or nations living under more primitive conditions, especially in Africa and Asia.

If we consider first the former category we find that approximately 3.1–5 per cent. of all human beings die from cancer. We are struck by the relative uniformity in the percentage of deaths from cancer, which indicates that within certain limits the conditions causing cancer are relatively constant and uniformly distributed over the civilized world. In this respect cancer resembles certain diseases which are caused by organisms evenly distributed over wide areas and to diseases primarily due to internal factors and not or only secondarily to parasitic agencies, while it differs from such diseases as smallpox, bubonic plague and poliomyelitis which are very irregular in their appearance.

If we compare the death rate from cancer in various countries we find the following figures: In a population of 10,000 die from cancer each year: in Switzerland 13.2, Norway 10, Holland 10.1, England 9.1, Austria 7.8, France 7.6, Prussia 7.1, Italy 6.1, Spain 4.8, Algiers (European inhabitants) 3.2. The death rate is also relatively low in Russia, Hungary, Servia, Jamaica and Ceylon. In Kyoto (Japan) it is approximately like Austria 7.9 per 10,000 inhabitants. On the whole the death rate from cancer is low in the countries around the Mediterranean.

In the United States in an area comprising one half of the population, the death rate per 10,000 inhabitants was (according to a report by the Health Commissioner of Pennsylvania (Dr. S. C. Dixon), 7.31 in 1907; the death rate in the United States is therefore very similar to that of Germany and Austria. Approximately 75,000 people die from cancer in one year in the United States and about half a million in the civilized world (F. L. Hoffman). If we consider only persons over 45 years old, considerably more people in the registered area of the United States die from cancer than from tuberculosis. Between the age of 45 and 60 years almost 7 per cent. of the male and 16 per cent. of the female population die in this country from cancer.

If we compare the death rate from cancer in the last 40 or 50 years we notice a universal increase in all civilized countries. The increase has taken place rather steadily and not by leaps. According to W. J. Whitney there was in Massachusetts from 1850–1910 during each 5 years an average but not quite uniform increase of 1.20 in the death rate for 10,000 persons over 30 years of age every five years. According to Dr. S. C. Dixon in an area comprising one half of the United States in population the death rate increased from 4.79 (1890)–7.31 (1907). In New York City there has been an increase from 5.4, which was the death rate during the 4 years ending 1882 to 8.1 during 1908–1912. A similar increase we notice in Germany, Norway, Amsterdam and everywhere else, where statistics are available.

While there can therefore be no doubt as to the actual increase in the death rate from cancer, the interpretation of this phenomenon is not quite clear. While some authors believe in a real increase, others believe it to be only apparent, due to improvements in diagnosis and to better registration. It is pointed out by some authors (especially by Bashford) that the increase in the death rate is found mainly in internal cancers which are difficult to diagnose. The increase concerns to a great extent cancer in the alimentary tract. This increase is found especially in persons over 60 years of age. Now in children cancer not rarely attacks internal organs, and still no noteworthy increase is reported in those cases. Furthermore errors in diagnosis would equally prevent physicians from diagnosing as cancer cases which are not cancer as well as from attributing to other causes deaths really due to cancer.

Furthermore the same increase has been noted in the well-conducted autopsies in the Charité Hospital in Berlin, where the diagnostic methods have not to any considerable extent changed within the last thirty-five years. According to Professor Orth, in autopsies on persons over 20 years of age cancer was found from 1875–1885 in 4 per cent., in 1904 in 10.7, 1909 in 19, 1911 in 20.8 of all the cases. It is, therefore, probable that a certain factor which is potent in the production of cancer has been gradually changed within the last fifty years causing a general increase in the cancer rate, while at the same time there has been a marked decrease in the death rate from tuberculosis in the corresponding period.

We will now consider the relative frequency of the different varieties of human cancer. Here we find again a similar distribution of the various kinds of cancer in all civilized countries in Europe, America and as far as we can judge at the present time also in Japan. The most frequent seat of cancer is the gastro-intestinal tract, especially the stomach, and in the second place the female generative organs, especially the cervix of the uterus and the female breast. Cancer of the stomach is approximately equally frequent in man and woman; in some countries it is slightly more prevalent among men. On the average 35–45 per cent. of all cancer affects the stomach and about 22 per cent. of all cancers develop in the female generative organs and breast. About 20–35 per cent. of all women who die from cancer have cancer of the uterus. Cancer occurs also relatively frequently at the lip, tongue, rectum and skin, especially of the face. Sarcoma is much less frequent than carcinoma. The relative frequency of the different varieties of cancer in the most populous areas of the United States is (according to S. C. Dixon) as follows: mouth 3.2 per cent., stomach and liver 38 per cent., intestines 11.7 per cent., female generative organs 14.3 per cent., breast 8.5 per cent., skin 3.7 per cent.

There occur, however, some notable deviations from the average rate of the different varieties in some countries. In Norway cancer of the uterus is relatively rare; only 6.3 per cent. of cancer develop in the uterus and 3.8 per cent. in the breast. In some parts of Norway cancer of the uterus is almost unknown. Cancer of the gastro-intestinal tract preponderates therefore considerably in Norway. In Sweden on the other hand cancer of the uterus is only slightly less frequent than elsewhere. In Switzerland also cancer of the stomach preponderates somewhat more than in the majority of other countries. A very peculiar deviation we find furthermore in Portugal, where cancer of the lip is very much more frequent than elsewhere (29 per cent. in men). While, on the whole, carcinoma of the male generative organs is rare (0.4 per cent. of all kinds in man), it is very frequent in the Cape Verde Islands. The proportion of cancer of the respiratory and excretory organs (kidney, ureter, bladder) is everywhere relatively low.

If we compare the incidence of cancer in the two sexes we find in most countries women somewhat more frequently affected than men. In Prussia the proportion is 3 men to 4 women. The relative incidence in women is even somewhat greater in the United States. The difference depends upon the difference with which various kinds of cancer affect the two sexes, and mainly upon the frequency of cancer in the female generative organs and breast; cancer of the gall-bladder, intestines, especially rectum, is also more frequent in women than in men, while cancer of the lip, tongue, skin, is more frequent in men. Cancer of the stomach is either equally frequent in both sexes or somewhat more frequent in men. In countries where cancer of the stomach prevails, and where a larger proportion of men than women are affected by this kind of cancer, the cancer death rate is higher in men, as in Switzerland, Norway and Kyoto (Japan).

There is no marked difference between married and single persons; the majority of statistical studies, however, indicate that married women are more frequently affected by cancer of the uterus and breast than unmarried women.

Sometimes we find the statement made that cancer is more frequent among the well to do than among the poor. It is doubtful whether this statement is correct. Some recent statistics point rather to the reverse. Again there seems to be in this respect some difference in the various kinds of cancer. Cancer of the cervix of the uterus appears to be more frequent among the poor, while mammary cancer is perhaps more frequent among the well to do.

There exists no marked difference in the incidence of cancer in country and city. On the whole, we are apt to find a somewhat greater incidence of cancer in the cities, especially in parts of the world where the number of physicians per unit of population is considerably smaller in the country and where therefore in all probability the number of unrecognized cases of cancer is greater in the country. The difference is therefore probably rather apparent than real.

There have been noted in various countries certain areas where cancer appeared to be more frequent than in others. Some observers believed especially damp-wooded country to be favorable to the development of cancer. Some physicians recognized certain houses or streets in villages or small towns, where the incidence of cancer was especially great. Behla for instance reported such an occurrence in the small Pommeranian town Luckau. These observers declared cancer to be "endemic" in certain localities and were often inclined to attribute this localized increased frequency to unknown infectious agencies. Although it is very difficult to interpret these observations, it does at present not appear probable that they ought to be referred to infection. Such cancer houses have been found only rarely: the number of cancers that occurred in these houses were relatively few, and furthermore cancer occurred also in the neighboring districts. Neither can we exclude the possibility that hereditary factors played a part in some of these cases. There is, however, no doubt that in certain parts of various countries cancer is more frequent than in others.

So far we have considered the incidence of cancer mainly among the white population of Europe and America. The incidence of cancer among certain races living under more primitive conditions is quite different. Among the negroes of Africa cancer is much rarer than among the whites of Europe and America. Although according to von Hansemann the same varieties of cancer occur there as in civilized countries, the proportion of the various kinds of cancers differs markedly. We find among the African negroes relatively frequently benign tumors of the connective tissue group as for instance lipomata (fat tumors). Sarcomata are correspondingly much more frequent than among the Europeans and it is furthermore very probable that the relative frequency of the various kinds of carcinomata is different. Also among the Arabs of Algiers sarcoma is more common than carcinoma. Among the male Arabs nine tenths of all cases of carcinoma occur in the face, which is especially exposed to the rays of the sun, and in the women carcinoma is more frequent in the vagina than in the uterus. Carcinoma of the gastro-intestinal tract is relatively rare. Also among the inhabitants of East India and Ceylon and among the Chinese we find a lower cancer rate than in Europe. In Japan however cancer seems to be relatively frequent as far as the available statistics indicate.

Also among the Indians in the reservation of the United States cancer is considerably rarer than among the white population (J. Levin). Differences in climate can therefore not be held responsible for these great differences in the cancer incidence. But is it due to inheritable race characteristics or differences in mode of living, preceding infection with other diseases? This question we can not answer definitely at the present time. Some facts however are of interest in this connection. W. Renne found that among the natives of Sierra Leone cancer is very rare; but since a more intimate intercourse between the natives and immigrated whites has taken place, cancer has increased in Sierra Leone. But even in this case we are unable to decide whether this increase is due to changes in the conditions in life or to the intermarriage between whites and natives. In the United States we also find that within the last fifty years there has been a considerable increase in the cancer incidence among the colored population. Cancer of the uterus, which was formerly rare among colored women, is now more frequent among the colored population than among the white. Here again we can not be sure how much of this increase is due to changes in the mode of living, to increase in the inflammatory conditions of the uterus, and how much to intermarriage.

In the case of the relative rarity of uterine cancer among Norwegian women, we again do not know whether it is due to the relative infrequency of preceding infections of the uterus or whether it is a question of race. Interesting problems thus present themselves as to the relative importance of race and of external conditions in the origin of cancer. More definite knowledge could be gained if in statistics a distinction were made between negroes and mulattoes; it would also be of interest to establish the frequency of uterine cancer in the first and second generation of Norwegian women in this country, especially distinguishing between those interspersed among the rest of the population and those living in close rural communities in which the original customs are preserved.

We mentioned already that on the whole carcinoma occurs especially in old age. In the United States the average of death from carcinoma is 60 years for males and 58 years for females. Between 45 and 64 years 7 per cent. of all deaths in the male and 16 per cent. of all deaths in the female sex are due to cancer (Hoffman). From the thirty-fifth year on the death rate from cancer increases rapidly. There seems to be an optimal age for the appearance of certain cancers which differs somewhat in various kinds of cancer. Whether the death rate from cancer as a whole increases with advancing age or whether there occurs a maximal death rate at a certain age after which there is again a decrease observed does not appear to be certain.

While the typical cancers which we have considered so far occur in the large majority of cases in older people, some cancers of the same type may appear in young people; thus carcinoma of the stomach, tongue, esophagus, appeared in very rare cases in children. But there are special kinds of cancer which appear typically in younger persons. This applies for instance to the "carcinoid" tumor of the appendix and to similar often multiple carcinomata of the small intestines, which are found in relatively young adults (Bunting). These tumors are much more benign than the typical carcinomata—they grow very slowly and make ordinarily no metastases. But certain tumors are quite typical for young children. While in adults carcinomata are considerably more frequent than sarcomata, in children sarcomata are much more numerous than carcinomata. The most frequent seats of cancer in children are neither the gastro-intestinal tract nor the female generative organs, but kidney and adrenal, next the eye, brain, skin, cranium and liver. And while the few carcinomata of the stomach and intestines in childhood are observed in 12–14 year old children, the tumors of the kidney appear often in infants.

Besides the sarcomata we find in young children frequently so-called mixed tumors, consisting of several kinds of tissue; in the kidney tumors for instance we may find side by side proliferating epithelial gland tissue, round cells resembling sarcoma, muscle and even bone-like tissue. In other organs also we find not rarely such mixed tumors to prevail among the cancers in children. Cancer of the female generative organs occurs in children not mainly in the uterus, as is the case in adults, but in the ovaries and in the vagina. In the eye and brain we find besides sarcomata which originate from connective tissue cells certain special kinds of structures, the so-called glia cells—which are related to nerve cells—to give origin to malignant tumors. Even in the abdominal organs there may appear in young persons tumor-like proliferations of cells derived from the sympathetic nervous system (Neuroblastoma of J. H. Wright).

There is still another class of tumors which occur especially in children and in young adults, but may occasionally be observed even in older people and which are of great interest, the so-called teratomata or embryomata. They have certain seats of predilection, as for instance in the pelvis in front of the sacral bone, or in the anterior mediastinum, even in the buccal cavity; however most frequently they are found in the ovaries and testicles. In these tumors are observed a great variety not only of ordinary tissues but of incompletely developed organs, as brain, eye, lungs, gut. These structures represent evidently malformed embryos. At first they grow usually slowly—in contradistinction to the typical mixed kidney tumors of children—but not infrequently somewhat later in life one or several of their constituent parts begin to assume a malignant growth, and even produce metastases.

Now the large majority of these tumors which appear in early childhood are in all probability congenital, they were preformed before the child was born; they are, however, usually noticed only at a time when they begin to grow somewhat more rapidly, and this may take place many years after birth; thus the sacral embryomata are often noticed first somewhere between the fifteenth and twenty-fifth years, when they begin to enlarge a little, and certain kidney tumors developing in all probability from misplaced embryonal adrenal tissue may even not become apparent until later in life. We may furthermore conclude that these congenital tumors of childhood and young adult life are in part due to localized aberrations during embryonic development, their composition of a mixture of tissues suggesting similar combinations of tissues which existed at such places some time during embryonic development. At that period certain tissues did not differentiate normally, did not become a functionating part of the organism restricted in its growth—but somehow preserved a part of the proliferative power which not fully differentiated embryonic cells usually possess and they exerted a destructive influence on the otherwise normally developed organism. The famous pathologist Cohnheim especially emphasized this origin of tumors; but he and still more so some of his pupils and followers extended the significance of their observations too far, explaining on this basis the origin of tumors in general, while their conclusion applies in all probability only to that class of tumors which appear in childhood and early adult life and perhaps to certain other related tumors. Recent investigations of Robert Meyer and others have indeed shown that certain minor embryonic malformations, especially in the region of the kidneys, the thyroid, thymus and eye are quite frequent; but that in the large majority of cases they certainly do not lead to tumor formation.

Other more or less benign tumors, which are often multiple, occurring simultaneously at different places are also frequently congenital, as for instance, growths consisting of lymph or blood vessels, cartilage, muscle tissue developing around small blood vessels, and fibrous tissue growths around nerves in certain areas of the body, furthermore pigmented moles.

However, not all the tumors found in the first half of life develop on the basis of embryonic malformations. It is very probable that many embryomata especially those of the ovaries and testicles owe their origin to the parthenogenetic development (development without previous fertilization) of a germ cell, a suggestion made more probable through the discovery of Jacques Loeb that in various classes of invertebrates ova can be induced by artificial means to develop without previous fertilization. And yet the majority of pathologists believe with Bonnet and Marchand that such embryomata just as other mixed tumors of childhood are due to embryonic aberrations, to a separation of early cells which are formed in the course of the early division of the previously fertilized ovum or to the abnormal fertilization of a little cell separated normally from the egg previous to the entrance of the spermatozoon.

However, this hypothesis can not be easily reconciled with the fact that the majority of embryomata appear in the germinal.glands (ovaries and testicles), an observation which can be readily explained, if we assume that these embryomata are due to the parthenogenetic development of ova in the ovarian follicles. This is the more probable as I found that in about 10 per cent. of the ovaries of young guinea-pigs formations occur which can not very well otherwise be explained than as embryonal structures, placental[1] as well as embryonic in the stricter sense, developing abnormally from ova in the ovarian follicles and gradually being destroyed by the surrounding tissues. A previous fertilization could be excluded in these cases.

Moreover in the ovaries of various mammals one can not rarely observe ova in athretic (degenerating) follicles which show the first, somewhat irregular segmentations, and in the armadillo as many as eight cells may, according to H. H. Newman, be seen.[2]

While these observations explain satisfactorily the relatively frequent occurrence of embryomata in the germinal glands, they may also explain the embryomata found at other places, inasmuch as it is known that the germ cells migrate in various directions in the developing embryo, before they reach the germinal gland. In some cases however blastomeres (cells formed in the course of the early segmentation of the egg) may form the matrix of the tumors, inasmuch as it has been shown in certain

[1] The placenta is an organ of partly embryonic, partly maternal origin which is attached to the uterine wall and which transmits nourishment to the embryo.

[2] The first cleavages of ova in athretic follicles of mammalian ovaries previously described by various investigators and also by myself can not all be explained as maturation divisions which precede the segmentation; we may see occasionally ova which have divided into a number of segments, several or the majority of which may contain nuclei and at the same time observe in two segments mitotic figures or their remnants, the position and character of these segments making it extremely improbable that they represent polar bodies (Leo Loeb, *Archiv f. mikroscop. Anatomie,* Bd. 65, 1905).

classes of animals that a detached blastomere may reproduce the whole organism.

We have still to consider one very interesting kind of tumor, namely, the so-called chorionepithelioma malignum, which also owes its origin to irregularities in the activity of certain embryonic cells but which in some respects differs markedly from the other tumors considered so far. When the segmenting egg attaches itself to the uterine wall it does not only produce the embryo proper, but it gives also rise to certain cells which attach themselves to the uterine wall of the mother, and are mainly concerned in transferring food from the mother to the embryo, thus forming the embryonal placenta, the outer layer of which is called the chorion. These chorionic cells, which are therefore of embryonic origin, migrate already under normal conditions deeply into the uterine wall; they may even penetrate into maternal blood vessels and be carried to other parts of the body of the mother. Usually these chorionic wander cells perish after some time in the mother, but occasionally they give rise to very malignant tumors which destroy the uterine wall, and form metastases (L. Fraenkel, Marchand).

Just as these chorionepitheliomata may be produced from the fertilized egg cell developing in the uterine wall, so they may occasionally owe their origin to egg cells which develop into embryomata in the germinal glands and especially in the testicle. Here likewise chorionepitheliomata may develop. In the structures which I found in the ovaries of guinea-pigs the greater part of the dividing egg cells formed in contact with and probably under the influence of the ovarian tissue of the mother placental tissue and especially migrating cells which penetrated occasionally even into the walls of the neighboring blood vessels.

We have now analyzed some of the factors concerned in the origin of tumors found in childhood and early adult life. We recognized that they are caused partly by abnormalities of embryonic development, partly by parthenogenetic development of germ cells. At least these are two of the factors concerned in their origin—whatever additional factors may be found in the future. However, the greater number of all tumors, especially the large majority of the typical cancers found in later life, owe their origin to different causes. We can appreciate these causes best, if we consider certain special kinds of cancer which are somehow associated with certain kinds of occupation.

In general the character of the occupation does not seem to have a marked influence on the incidence of cancer, although it seems that cancer in certain callings (agricultural and forest workers, textile and wood workers, domestic servants) is somewhat more frequent than in others (miners, soldiers, factory workers in general). There are however certain occupations in which a direct connection exists between the character of the work and the development of cancer. For instance in Röntgen ray technicians, especially in those who began their work, in the first years following the discovery of the rays, when the dangers connected with this occupation, the various precautions used at the present time were as yet unknown, gradually, often after many years of work, a painful condition of the skin arose, mainly on the hands and arms which were exposed to the rays, it became thickened, cracked, ulcers formed. The epithelium grew further down into the deeper tissues and slowly a carcinoma developed which later made metastases.[3] Approximately 70 cases are known where cancer thus developed, and in some cases it developed a considerable time after the exposure to the Roentgen rays had ceased.

Chimney sweeps develop relatively frequently cancer of the skin, especially of the scrotum, and it is interesting that this cancer may be found in young people. It has for instance been observed in a boy eight years old. The cause of this cancer is the irritation produced by soot. Those who are employed in the distillation of tar (especially of gas work tar) in the manufacturing of grease and briquettes are liable to develop cancer of the skin. Certain organic substances contained in tar and pitch cause the development of warts on the skin, which later break down and become transformed into cancers. In men employed in the manufacturing of aniline dyes, and certain other benzol derivatives, wartlike excrescences of the skin may appear; but especially interesting is the frequent appearance of cancers of the bladder in such cases. Each of the affected men had been in the dye works for 20 years or more. Evidently substances excreted through the kidneys exert in such cases an irritating action on the epithelium of the bladder.

There are some other occupations in which certain substances are the direct or indirect cause of the development of cancer. Just as Röntgen rays and certain chemicals, so may also light rays under certain conditions be the cause of cancer, especially in sailors, in whom sometimes the skin of that part of the body which is exposed to the light shows certain changes which lead gradually to the development of cancer. We notice also occasionally in old people and in rare cases even in young men in the face and on the hands, in parts therefore exposed to the action of the light rays, the development of multiple lesions, which in the course of time become transformed into carcinoma. There occurs furthermore in children a congenital skin disease, xeroderma pigmentosum, which develops usually into a carcinoma at places exposed to the light rays.

Very instructive is the cancer which is not rarely found in Kashmir among the carriers of the kangri, a little stove, which burns the skin on which it rests. Gradually cancers develop in the scars; the downgrowth

[3] *Cf.*, the careful microscopical studies of S. B. Wolbach.

of the epithelium is at first slow, but later metastases form in the lymph glands and a typical malignant carcinoma is now present (E. T. Nere).

Related processes—namely the gradual transformation of epithelium into cancerous growth—have been observed in cases of chronic ulceration of various kinds with incomplete healing of the epithelial surface as for instance in the case of the chronic ulcer of the leg, in the case of lupus, a tuberculous skin affection and in other similar conditions. Another class of cancers is produced directly or indirectly through the action of certain parasites, especially of certain worms (nematodes and trematodes). Thus in Egypt infection with bilharzia (*Distoma hæmatobium*) is relatively common. This trematod lives in the veins of the abdomen and lays its eggs in the mucosa of the bladder; they cause inflammation in the bladder, mostly in older persons, and later cancer develops in about 3½–5 per cent. of patients infected with bilharzia. In Bosnia, after bites of sandvipers, chronic ulcers without a tendency to heal may develop, and they may become carcinomatous. Also in other cancers a causal connection between a metazoan parasite and the tumor has been suggested in man, but this connection can not yet be considered as proven. Thus Askanazy found in a case of primary carcinoma of the liver *Opistorchis felineus,* while in Japan in similar cases a *Distoma* has been observed. In cases of chronic trichinosis carcinoma was found in organs which were situated in the neighborhood of the infected muscles. The presence of certain mites were noticed by Borrel in the case of mammary cancers and considered as its cause. It appears however that these latter parasites are just as frequently found in the non-cancerous breast as in cases of mammary cancer. The importance of nematodes as the cause of certain cancers in animals has been recently demonstrated, as we shall later explain more in detail. Of especial interest is the fact that while in the large majority of cancers caused by external irritation carcinoma developed, a few sarcomata have been observed in the skin under the influence of Röntgen rays, in the bladder in aniline dye workers and in persons infected with hilharzia.

We see then that under the influence of a considerable variety of agencies, cancer can develop in the human body and that in many cases cancer is preceded by the formation of warty or papillomatous excrescences and in other cases by long-continued ulceration, which in itself seems to be able to lead to the formation of cancer. At present we leave out of consideration the mechanism through which these agencies produce cancer, especially the question whether their action consists in a direct specific stimulation of the epithelial cells by the light and Röntgen rays, chemical substances and parasites or whether all these agencies act indirectly causing primarily ulceration, which later is followed by the development of cancer. We know indeed that chronic ulceration due to various causes may in itself lead to the development of cancer. Later we shall have occasion to return to this question.

We mentioned already that certain pathological conditions prepare the soil for the subsequent development of cancer, such as for instance lupus, chronic ulceration of the leg. But there are numerous other morbid conditions which stand in a certain causal relation to the growth of cancer. Gastric carcinoma originates in a considerable number of cases at the site of a previous ulcer of the stomach. Long-continued suppuration in the middle ear, fistules of various parts of the body may be followed by the development of cancer; so may certain affections, in which either certain parts of the skin or the mucosa are covered by plaques of horn, so-called (leukoplakia of the tongue and vulva, psoriasis). In the mammary gland chronic inflammation may lead to the subsequent development of cancer. Carcinoma may be preceded in the thyroid by goitre, in the liver, by chronic inflammation leading to an increase in fibrous tissue (cirrhosis), in the prostate by hypertrophy which is relatively common in old men. Inasmuch as certain conditions predisposing to cancer may be caused by syphilis, also syphilitic infection is indirectly one of the causes of cancer.

We mentioned previously that xeroderma pigmentosum, a congenital lesion of the skin, becomes usually cancerous. We furthermore know that certain at first benign tumors may later be transformed into cancers. Thus papillomata (polypus or cauliflower-like outgrowths) very often precede cancer of the small and large intestines or of the bladder. These papillomata are in the intestines frequently caused by preceding long-continued irritation; in certain cases however they are congenital. Pigmented moles of the skin if constantly irritated may be transformed into a pigmented cancer which is often very virulent.

At first benign tumor-like proliferations of the epithelium of the liver, mammary gland, ovaries, uterus, and especially glandular tumors (so-called adenomata) may later become transformed into carcinoma. As we have already mentioned, certain parts of teratomata at various places of the body are not rarely changed into carcinoma or sarcoma. The usually benign muscle tumors of the uterus (myomata) are in 6–10 per cent. of all the cases transformed into tumors resembling sarcomata, a change which does usually not take place before the patient has reached the fortieth year. In other cases, however, such myomata of the uterus are only the indirect cause of the development of cancer, the mucosa in their neighborhood becoming converted into carcinoma. Possibly the constant irritation caused through the pressure of the muscle tumors upon the epithelial lining of the organ may be responsible for this transformation. Furthermore, fat tumors (lipomata) may occasionally assume a malignant growth and become sarcomatous or soft, mucus-producing tumors (myxomata) which may be malignant and may metastasize.

Long-continued irritation is not always necessary but in certain cases one single traumatism may undoubtedly cause the development of cancer. While, however, long-continued irritation usually leads to the formation of carcinoma, one single traumatism causes more frequently the development of sarcoma. Thus cases are known in which two months after a blow on the eye a sarcoma began to grow at the place of injury; in a child sixteen months old a sarcoma of the ciliary body of the eye developed after a blow; a sarcoma of the arm followed a stab wound at the site of injury. There are also cases on record in which a bone sarcoma developed after a fracture of the bone and after an extraction of a tooth the development of a cancer has been observed in the jaw. Also other than connective tissues may assume a rapid cancerous growth after an injury, as for instance the glia cells of the brain which are of the same origin as the nerve cells. Also carcinomata of the jaw originated subsequent to an extraction of a tooth. A carcinoma of the testis followed six weeks after an injury received from a horse.

In all these cases we have to distinguish between two possible results of the traumatism; the latter may either actually cause the new formation of a cancer or it may merely increase the rate of growth of a tumor that existed previous to the injury, which however only became apparent after the injury had increased the rapidity of the tumor growth. The latter condition existed for instance in the case of an embryoma of the testis which assumed a rapid growth after an injury, taking on the characteristic of a malignant tumor with subsequent formation of metastases.

We have now learned to know several sets of conditions which are either alone or in combination with other factors responsible for the occurrence of cancer, namely: (1) Irregularities of embryonic development. (2) Parthenogenetic development of ova. (3) The long-continued action of external stimuli, as for instance Röntgen and light rays, various substances acting chemically, long-continued ulceration and certain parasites. (4) Traumatism.

In certain of these cases we can state definitely that a combination of several factors had to come into play before carcinoma developed, for instance, in those cancers which follow xeroderma pigmentosum. Here a congenital lesion becomes converted under the influence of an external agency—namely, the light rays—into cancer. A pigmented mole is the result of some irregularity of embryonic development; it is present at the time of birth, and therefore a congenital lesion; mechanical stimuli cause its transformation into cancer.

We recognized that the majority of cancers of childhood differ in a definite way from the typical cancers of old age. We found reason to believe that certain embryonic irregularities are in part at least responsible for many cancers of childhood and early adult life. In the light of the data which we gave concerning the significance of external stimuli in cancer, let us now briefly survey the typical cancers of old age. Such a review will demonstrate that for the production of the majority of all cancers the long-continued action of external stimuli is of the greatest importance. We stated that in civilized countries the large majority of human cancers occur in the alimentary and female generative organs, while the respiratory tract and kidney and ureter and the nervous system are much more rarely affected. The alimentary tract is the one through which the solid substances pass and which is therefore most easily exposed to constant irritation and possibly the action of certain parasites while through the respiratory and excretory tract (kidney, ureter) only gaseous substances or liquids pass; there is here therefore much less opportunity for long-continued irritation, and consequently less cancer. In the alimentary tract, those parts in which mainly fluid material is present, namely the small intestines, are least affected, while those in which especially solid material stagnates as in the stomach and rectum, cancer is most frequent. Cancer of the lip is frequently caused through the irritation of a pipe, cancer of the tongue and cheek is sometimes the result of constant irritation on the part of a defective tooth or prothesis. In the esophagus those places are the favorite seats where there is the greatest opportunity for irritation; in the stomach cancer is frequently found at the same site where gastric ulcer occurs most frequently and where the foodstuffs are apt to press against the pylorus in entering the small intestines. Certain chronic digestive disturbances characterized by a decrease or lack of digestive substances secreted by the stomach (achylia gastrica), in which there is therefore more irritation as a result of insufficient liquefaction of the intaken food, may also be followed by cancer. Irritation caused by the consumption of alcoholic beverages seems, in certain countries in which cancer of the stomach is more frequent in men than in women, to be one of the causes of gastric carcinoma. In the intestines cancer is frequently preceded by the formation of papillomata which again are in most cases the result of chronic irritation and inflammatory processes. Cancer of the gallbladder is more common in women, because women more than men are, as a result of certain habits, prone to suffer from gallstones, and gallstones cause a condition of constant irritation in the gallbladder. Carcinoma in the bile ducts has been observed to originate at a place where a gallstone was most likely to find obstruction in its passage into the intestines.

In the female generative organs cancer is most frequent in the cervix of the uterus, where, as the result of preceding labors, and of infection, tears and chronic inflammatory conditions are found to occur. In the mammary gland also cancer stands often in causal relation to preceding inflammatory conditions. In the ureter cancer has been found in connection with an incarcerated stone. In the respiratory tract cancer in the nose may follow a disease, ozæna, while in the larynx cancer originates most frequently in the vocal chords which, through their situation and function, are most exposed to various external injurious influences.

This may suffice to prove the great significance of the continuous action of external stimuli in the production of the majority of the typical cancers of more advanced age.

While in general we can very well determine the dividing lines between the fields of the typical tumors caused through the action of external stimuli and those due to embryonic disturbances, there may in individual cases be some doubt. A number of pathologists extended it seems unduly the field of the tumors belonging to the latter class. They believed that microscopic studies of early tumors frequently demonstrated that they took their origin not from cells attached in a normal manner to the rest of the organs but from detached small fragments of organs. There would have been good reason to interpret the existence of islands of disconnected cells as an indication of imperfect embryonic development. Careful microscopic investigations show however that in the typical cancers of the stomach and intestines (Hauser, Versé)—with the possible exception of certain atypical so-called carcinoid tumors of the small intestines—and even in the multiple tumors of the skin (Janeway, Loeb and Sweek) the cancers originate through a direct downgrowth of the surface epithelium into the deeper tissues. Conditions preceding the development of carcinoma cause primarily an increased proliferative power of the epithelium which, as the result of this change, in the large majority of cases grows down into the deeper tissues and destroys them, but in some cases the resistance of the deeper tissues is so great that it successfully counteracts the invasion or dissolving power of the epithelium and the latter may instead of growing downwards be forced to grow towards the outside of the skin, as we could observe in a case of multiple carcinoma of the skin. This increased proliferative and infiltrative power of the epithelium is therefore the principal characteristic of cancer.

This change in the proliferative power of the epithelium may be accompanied by a change in the structure of the affected cells, which appear often less differentiated. This loss in the complexity of proliferating cancerous cells has been called anaplasia. In other cases, however, this morphological change in the proliferating cells may be entirely absent, as for instance in some beginning Röntgen ray cancers.

Still furthergoing structural modifications of the proliferating cells may take place in the secondary (metastatic) growths, although on the whole metastases repeat more or less the structure of the primary tumor. Thus we may in the case of a primary carcinoma of the liver find metastases in which the tumor cells continue to produce bile just as the normal liver cells do, and especially primary as well as metastatic tumors of the thyroid may be hardly distinguishable from the normal tissue from which they are derived.

Microscopic studies of early stages of cancers showed furthermore that in many cases the growth starts at one well-defined rather limited area of the affected tissue; and that all the tumor masses developing subsequently are derived from the relatively few cells which were originally seen to proliferate. In other cases, however, the tumor growth originates at several neighboring places simultaneously. And in still other cases a certain tissue may, over a wide area of the body and even at distant places, give rise to cancer formation simultaneously or successively. In such cases we may assume that some change predisposing to the development of cancer has taken place in the affected tissue, and that relatively slight external stimuli, as for instance an injury, effect of light, are sufficient to call forth the actual cancerous proliferation.

Usually the proliferating cancer cells do not infect neighboring cells with which they may come in contact during their proliferation. While as a rule the neighboring normal cells do not become cancerous in contact with cancer cells, this does not hold good generally; and as we shall see later the study of animal cancer has shown that such transformations may take place under certain conditions.

The careful microscopic studies of many pathologists (among American investigators we might cite among many others: Councilman, Mallory, Ewing, LeCount, Warthin, Wilson and MacCallum) have contributed many important and interesting facts concerning the structure of various tumors, their resemblance to and deviations from the structure of normal organs from which they are derived and such studies formed the basis of a more detailed classification of tumors (von Hansemann, Adami). We have learned that each organ or tissue gives rise to specific tumors which not only differ in structure and metabolism, but also in their proliferative and metastasizing energy. It will, however, not be necessary to discuss these differences more in detail on this occasion.

Before leaving the problem of human cancer we will briefly consider what part heredity and microorganisms play as the cause of tumors in man.

Heredity is undoubtedly a factor in those cancers which develop occasionally in cases of xeroderma pigmentosum or from pigmented moles. We know that here the conditions preceding cancer are hereditary and therefore cancer itself is indirectly hereditary. We furthermore know that a certain class of cancers originates on the basis of embryonic malformations, and inasmuch as these are under certain—as yet not well defined—conditions hereditary, we may assume that certain cancers belonging to this class are also hereditary. There is indeed some evidence which points to this conclusion. There is for instance a case known in which both the mother and her one and one fourth years old child became affected by glioma of the retina (a tumor originating in modified nerve cells of the eye). In another case a twenty-one-year-old man had 17 osteomata (tumors consisting of bone tissue) symmetrically arranged and his father had similar tumors. It is furthermore known that in certain cases polyps of the intestines are congenital and occur in several members of the same family. On the basis of such polyps cancer not infrequently develops. We have therefore reason to believe that heredity plays a rôle in a certain number of that type of cancers in which flaws in embryonic development are a factor.

In the case of the typical cancers of later life in the causation of which as we stated external stimuli play such a prominent part, it is very much more difficult to determine the significance of heredity. We know that the frequency of cancer varies very much in different races; but we have also seen that we can as yet not be certain how much this difference is due to factors inherent in the race (heredity) and how much it is due to variations in the mode of living and to preceding inflammatory conditions in the affected parts of the body. The ordinary methods of vital statistics which almost exclusively have so far been applied in cancer seem to show that in about 14–18 per cent. of persons affected with cancer other cases of cancer occurred in the family. Now it is doubtful whether this incidence is greater than should be expected according to the law of probabilities. Even extensive statistical studies of this character can evidently not solve the problem. We must rather turn to intensive studies of the incidence of cancer in various families for a solution. There are indeed already some data available which seem to indicate the existence of a hereditary factor also in the causation of the typical cancers of more advanced age. In certain families, as for instance one reported by Broca, the incidence of cancer has been extraordinarily high. A. C. Garmann found that in a certain district of Norway, the population could approximately be divided into 20 distinct families, and 72.8 per cent. of all cases of cancer occurred in a single one of these 20 families. J. Levin has begun to use the statistical material collected at the Eugenics Record Office of the Carnegie Institution in Cold Spring Harbor for such intensive statistical studies. In one family on which he has reported recently he found, that a fraternity in which one or more members suffer from cancer, usually shows in a previous generation a cancerous member either on the paternal or maternal side or on both sides. It may be expected that a continuation of such studies will decide definitely the problem as to the significance of heredity in human cancer. As we shall see later, in the case of animal cancer the great importance of heredity has recently been established.

Especially since the discoveries of various microorganisms as the cause of certain diseases, the possibility was always in the minds of investigators, that also in cancer besides the conditions enumerated microorganisms might be responsible for the cancerous cell proliferation. We must of course remember that our present knowledge of the factors underlying cancer was only gradually acquired; furthermore that certain experiences concerning animal cancer which we shall discuss later, suggested microorganisms as the direct stimulating agencies while the other factors which we analyzed so far would represent merely indirect causes, making the infection with microorganisms more easy. We know indeed that to a certain extent microorganisms can call forth cell proliferation. Thus the tubercle bacillus may cause a limited growth of connective tissue and as especially Borrel has pointed out the organisms causing smallpox and vaccinia may even produce a slight proliferation of the infected epithelium. But in all those cases the proliferation soon ceases and toxic substances produced by bacteria lead usually soon to the death of a great part of the newly-formed cells.

Based on such considerations many attempts have been made to prove the constant presence of certain parasitic microorganisms in human cancer. Under the microscope it is possible to recognize in cancer cells certain inclusions which are usually absent in normal tissues and a number of investigators claimed such included bodies definitely as protozoa (among others, Thoma, Sjoebring, Leyden, Gaylord and Eisen). Even the life cycle of these protozoa was apparently determined by some of these authors. It could, however, be shown that similar cell inclusions may originate otherwise and did in all probability therefore not represent protozoa. Also bacteria (Doyon), mucor (Schmidt), chytridiaceæ (Behla) and other microorganisms were held responsible. Others (Sanfelice, Leopold) believed yeast-like organisms to be frequently demonstrable in human cancer; they cultivated some yeasts in culture media and by injecting the organisms into animals believed to have reproduced the disease. Careful studies by many investigators, however, could not confirm these interpretations. In the case of yeasts it has for instance been shown that although they occasionally occur in cancers, they are on the whole rare and do not reproduce the disease if injected into animals (Busse, Nichols, Loeb, Moore and Fleisher). They act in the body in a similar manner as inert foreign bodies, and we found a yeast which we isolated from a sarcoma to lead, after intravenous injections, to the death of the animal through occlusion of the kidney tubules, without ever producing cancer.

These persistent claims of the discovery of a microorganism as the cause of cancer which could in no case be substantiated led in the case of many pathologists, especially of those mainly interested in the careful study of the structure of pathological tissues, to a reaction which induced them to deny the possible importance of microorganisms in the causation of cancer; they were inclined to hold on the whole the factors already established as sufficient to explain the origin of cancer. On the other hand, a number, especially of experimental investigators, without being able to accept as valid any of the claims as to the discovery of a microorganism as the cause of human cancer, always pointed out the possibility that microorganisms might at least in a certain number, perhaps even in a majority of cases, be a factor in the production of cancer and tried to find new experimental means to approach these problems; accordingly on various occasions we pointed out the possibility that ultra-microscopic, perhaps intracellular, microorganisms might induce body cells, under certain conditions, to proliferate in such a manner that cancer resulted. However, in no case of human cancer has the causative significance of a microorganism so far been proven. We shall see later on that in a certain kind of animal cancer this proof has recently been supplied by Peyton Rous.

# PSYCHOLOGY: SCIENCE OR TECHNOLOGY?

By E. B. TITCHENER

PSYCHOLOGY has, of recent years, been exhorted to be practical, praised for its willingness to be practical, blamed for its unwillingness to be practical. "A kind of psychology which is needed is that of every-day people." "Psychology is ceasing to be a purely academic science and is now willing to study questions dealing with every-day life." "Psychology as it is being taught and investigated deals with matters of no concern, or of too abstract a nature, for practise." "The normal psychologist has been forced out of his academic reserve." A psychology is needed "which is aimed at practical ends," "a psychology which works and lives rather than a psychology easy to teach or easy to write," a psychology of a "matter-of-fact type," which adopts "the common-sense attitude," a psychology whose problems "really go at the causal relationships vital to the student, vital to any layman who wants to know what psychology is and does, vital to the physician,"—in a word, a truly "dynamic" psychology. The demand, as these few quotations show, far exceeds the supply; exhortation and blame are more strongly in evidence than encouragement and praise.

If, now, such amenities meant simply that there is a family quarrel among psychologists, or if the attack upon theory and the call to practise were confined to psychology alone, then discussion and reply would find their proper place in some technically psychological journal. It seems, however, to a lay reader of scientific magazines, that the stir in and about psychology is typical of what is just now going on in many other fields of scientific work, and that the issue between theory and practise has been raised in many quarters. That would, of itself, be good ground for appeal to a general scientific audience; but the present writer has a second reason for bringing discussion into the open. He believes that, so far as the matter may be argued, so far (that is to say) as we leave out of account temperamental differences and idiosyncrasies which are beyond the reach of argument, hostilities are in the main kept up through the neglect of a very elementary distinction, the distinction of Science and Technology; and he believes that, if that distinction is regarded, there may be an end of railing accusation and a new birth of what theory and practise both alike require—serious and well-weighed criticism. It is true that the mere expression of this belief may defeat his purpose: the practically-minded reader may refuse to read further;

for the practical man is nothing if not outspoken in his dislike of hair-splitting distinctions and formal definitions. Let it then be said, at once, that there shall be no formal definition in the present paper, and that there shall be as many loose ends left as the most matter-of-fact common sense can desire. The distinction to be drawn is, in truth, elementary, and the drawing will here be done in the grossest way.

What follows, therefore, is an attempt at an *eirenicon;* and it begins at the beginning, with the question—What do we mean by science?

## I

We are still told, in text-books and scientific addresses, that the various sciences represent various *departments* of knowledge. The territory of science, that is to say, is conceived of as parcelled out among the separate sciences, very much as a continent is mapped out into a number of adjoining countries. If the tale of the sciences were complete, the whole map would be variously colored; since, however, there are "gaps" in our knowledge, the map shows blank spaces, unexplored regions to which the methods of science have not yet attained. "The gaps are being filled; we are no longer isolated, but are working side by side on adjacent areas which are inseparably connected;" so said the president of the recent Medical Congress; and the figure was probably as familiar to his hearers as it fell naturally from his own lips.

A figure of this sort, however uncritically it may afterwards be employed, is always suggested in the first instance by some aspect of the facts; and in the present case the suggestion is not only obvious, but is also continually renewed. Few of us would hesitate to say, offhand, that the "tree" belongs to the province of botany, and the "inclined plane" to the province of physics. The things that we find in our surroundings fall, as we say, into groups, as subject-matter of this or that science; and the sorting or classifying of things, which is perhaps the earliest form of man's intellectual mastery of his world, still suffices for practical purposes and may, as our quotation shows, prove to be sufficient also in scientific contexts. That figure, nevertheless, together with the principle of classification which it implies, must now be discarded; the sciences can not be looked upon as departments of knowledge, adjoining and mutually exclusive, each one covering and exhausting a certain tract or region of experience, and each one concerned with a separate kind of subject-matter. The tree, we said, is placed by our ordinary thinking in the province of botany; yet this same tree may be considered from the points of view of taxonomy, ecology, distribution, morphology, physiology; it may be discussed by chemistry, or by general biology; and finally as look and feel it belongs, with all the looks and feels, to psychology. The inclined plane is in a like ambiguous position. These are, no doubt, trivial examples; but they serve to bring out the fact that one and the same item of human experience may enter, as part of their subject-matter, into a large number of sciences; whence it follows that the sciences themselves can not be distinguished, in any final accounting, by the specific character of the "objects" with which they deal.

What in fact differentiates science from science is, as an earlier sentence has hinted, something that we may term objectively *point of view* and subjectively *attitude.* Giving up the figure of the map, one might conceive of the world of experience as contained in a great circle, and of scientific men as viewing this world from various stations upon the periphery. There are then, in theory, as many possible sciences as there are distinguishable points of view about the circle. Every science seeks to view the whole world of experience from its particular station; and every science deals, from that station again, with identically the same subject-matter, namely, with human experience. The separate sciences are, therefore, not at all like the countries on a map; they are rather like the successive chapters of a book which discusses a complex topic from various points of view. In this sense, they overlap; they are mutually complementary; no one of them in truth exhausts experience or completely describes the common subject-matter, though each one, if ideally complete, would exhaust some aspect of experience.

It is, then, from some such figure as that of the circle and the men around it that a classification of the sciences must start. We must add, however, both for the sake of clear thinking and to forestall criticism, that the figure does not "work"—it loses its regular outline and at the same time grows more complex—when we come down to details. Thus, to say that the world of experience is a circle is to say that all the sciences, at least in their ideal completion, are coextensive; and to say that the sciences are views of the world obtained from standpoints about the circle is to say that all the separate sciences are, as sciences, coequal; and both of these statements may fairly be challenged. Such matters of detail, difficulties as they are to those who attempt a classification of the sciences,[1] need not however detain us; the fundamental idea of our figure is sound. The figure itself helps us even a little further; for the question how it comes about that men can take up their stations around the circle, and so view human experience as if from without, is evidently the problem of a theory of knowledge, of logic in the broader sense; and the question of the essential nature of the whole, of experience viewed and experiencers viewing, is as evidently the problem of a metaphysics.

[1] Flint's essay on classification in "Philosophy as Scientia scientiarum" is of very uneven merit, but contains much valid criticism and is useful as a general survey of the field. Flint remarks that "the fundamental sciences are not classed according to individual objects. Every object is complex and can only be fully explained by the concurrent application of various sciences."

With the latter discipline, science has nothing to do; with the former, as we shall soon see, it has a great deal.

## II

If, however, there are certain difficulties which we may, in the present connection, rightly pass over, there is a further question which can not thus be avoided. We are bound to characterize more closely the *scientific* attitude, or the *scientific* point of view. Human experience may be brought together in other than scientific ways; and while we still need not seek for formal definition or final classification, we must try at least to differentiate science from the appreciating disciplines and from what we have called technology. We must find distinguishing adjectives for the attitude itself, for the method which it implies, and for the problem which it discovers.

The history of science leaves no doubt of the answer to be given to this threefold question. The attitude of science, to begin with that, is before all things a *disinterested* attitude: witness the rise and growth of astronomy, of chemistry, of physiology. Until mankind has learned to take experience in serious earnest "for its own sake," to subordinate personal ends to the pursuit of truth, there is no science, but only something which at its worst is quackery and pseudo-science, at its best common sense and rule of thumb; and conversely, so soon as a man starts out to examine some aspect of experience as if it were for itself important and knowledge of it were intrinsically desirable, so soon does the germ of a science appear. For the race, the learning of this lesson was difficult enough; and so, in the large, the negative form of the adjective—dis-interested—may be justified; science sets aside the oldest and what we might consider the most natural interests of man. For the individual, on the other hand, a positive term would be more suitable. The curiosity or, as Helmholtz named it, the *Wissensdrang* which marks the scientific temperament renders the "disinterested" work of science the most interesting thing, as Helmholtz also said, that its possessor can find to do. The adjective must be kept, partly for its historical associations, and partly because the writer can not think of a positive word that should replace it; but it must be understood, when the worker in science, the scientifically-minded individual is in question, as meaning self-fulfilment rather than self-renunciation. Otherwise, science would never have had its martyrs.

The scientific attitude, then, is disinterested; the point of view of science is one that shall reveal the unvarnished fact; so much we are plainly taught by the history of science. We gather from the same source that the method of science is *observation*. All the "facts" of science are gained by a disinterested observation; sometimes, by an unaided observation; more often, since the conditions are complex, by the roundabout way—which is still observation—of experiment and measurement. We need not pause to illustrate, or to cite the authorities; the conclusion is generally accepted; and every piece of apparatus in our laboratories shows as an instrument for the control or the extension or the refinement of observation.

It is, perhaps, less apparent that all the problems of science may be summed up in the single problem of *analysis;* that the task which lies before the man of science, in his character as scientific, is always the analysis—under which is included, of course, that synthesis which is a test of analysis—of some complex object or complex situation. The reduction of a compound to its elements, the differentiation of factors, the establishment of correlations among the components of a given whole,—these are the things that the scientific investigator finds himself doing. True, we shrink a little from running all men of science into the same mold; we individualize them; we think of Newton as wielding "the ponderous instrument of synthesis," of Darwin as "working on true Baconian principles, and without any theory collecting facts on a wholesale scale." We are right in thus individualizing; for not only is the man of science something more than a scientific machine, but science itself is also (as we are to see in a moment) something more than what we have so far made it out to be. The witness of history is, nevertheless, straightforward enough; what Newton and Darwin, as scientific men, had before all things to do was to analyze, and to analyze again, and again to analyze. To be scientifically active is disinterestedly to apply the method of observation to the task of analysis.

## III

Our three adjectives are thus given: disinterested, observational, analytical. Taken together, they characterize the scientific attitude with sufficient accuracy for the purposes of this essay. They do not, however, cover the full meaning of "science" as that word is ordinarily used and understood. When we speak of science, we mean, not an assemblage of observed facts, the direct results of analysis, but rather an organized and systematized body of knowledge, a closed and self-contained whole. That every science, every transcription of the world from a scientific point of view, should yield a system, as if there were of necessity some immanent principle of order which the facts illustrate and to which they conform, is of course an assumption, and an assumption that we might find curious were it not so familiar. Originating perhaps in physics, supported by the belief in the general uniformity of nature, and favored by the tendency to regard the sciences as departments of knowledge, and therefore as concerned with divisions of the cosmic mechanism, it has been accepted, more or less consciously, by biology and psychology. Whether the acceptance was wise, and whether economy of thought may not be paid for too dearly, are questions beside our immediate point. What we have to note is this: that to systematize the facts of science, by any principle immanent or external, is to bring logic to bear upon them, to arrange them in the light of those logical laws which the experience of the race has tested and found secure, and which therefore form the stock-in-trade of a beginning theory of knowledge. We proceed, says Bacon, "by observing or by meditating on facts"; "to the formation of a science," writes Whewell, "two things are requisite,—Facts and Ideas; observation of Things without, and an inward effort of Thought"; and Huxley demands for a science "scientific observation" and "scientific reasoning." Science, that is to say, in the meaning of a scientific system, is the outcome of scientific activity ordered by logic.

It is only, be it remarked, when we thus consider science as a system, that we can at all subscribe to Huxley's definition of science as "organized" or "perfected common sense." Scientific activity is almost the antipodes of common sense. For science is disinterested, and common sense is self-centered; science is observational, while "there is not one person in a hundred who can describe the commonest occurrence with even an approach to accuracy"; and science is analytical, while common sense, as Huxley shows by reference to "the natural object Water," is content with gross appearance and total function. Common sense is the average man's intellectual *modus vivendi;* and the one practicable bridge that connects it with science is the bridge of logic; the average man is, in his own way, a very Aristotle. Were that bridge to fall, the definition would be impossible; we should have merely the occasional instances in which the points of view of science and of common sense coincide,—limiting cases, too few to provide even stepping-stones from the one to the other.

Science, therefore, may mean two things, scientific activity and the scientific system; and this twofold meaning is a fertile source of confusion. There is always the danger, for instance, that logic, which is a good servant, become the master,—as it does when Pearson tells us that the goal of science is "nothing short of a complete interpretation of the universe." Science, as scientific activity, aims at no goal; even the phrase "pursuit of truth," useful and inevitable as it may be, may also be misleading; science is, in strictness, only self-directed upon an endless task. So the result of scientific activity is not an interpretation, in any pregnant sense of that term, but only a transcription of the world of human experience as it appears from a certain point of view. Science, in Pearson's formula, thus stands for the system of science; and the system in turn is made to stand, not only for the outcome of scientific activity as worked over by an accepted theory of knowledge, but also for a special theory of knowledge under which the outcome of scientific activity has, to Pearson's satisfaction, been subsumed; logic has become the master. The same logic is, none the less, an indispensable servant. We may set aside the whole business of making systems: yet we shall never plan an investigation, or carry out a research, or present our results to our fellow workers, without calling in the aid of logic. Scientific activity and logical activity are always and everywhere intermingled; a book like Jevons' "Principles of Science" is, in the nature of the case, very largely a logic; it is logic that adds the subjunctive and imperative moods to Poincaré's scientific indicative. And if, for all these reasons, the clean distinction of the two activities is intrinsically difficult, it becomes the more so in the concrete case, seeing that the specialist in science is likely to employ a special logic, the logic of his special point of view and of the "facts" which that point of view discloses, so that he seems presently to work by "intuition" and the activities appear to have been blended rather than intermixed.

Still, the activities are in themselves different; and in the main, in the broad, our thinking must recognize their difference. We are, again, not to split hairs, or to attempt any hard and fast distinction. But let the reader take up a text-book—that very practical thing—in some one of the newer sciences; let him go through it, pencil in hand; and let him mark, as he reads, the passages that are derived from scientific activity on the writer's part and the passages that are logical. Sometimes, of course, he will be in doubt; and the doubtful passages, since we are making but a rough and ready test, may be left unmarked. They will occur most often in the early chapters of the book,—partly because the introductory chapters are likely to be of a general character, partly because the reader is not yet skilled to distinguish the one sort of writing from the other. As more and more pages are turned, the marking becomes easier, more prompt and more certain; the reader feels that he has the key to the cryptogram; and the result is instructive enough to warrant the few hours that have been given to the task.

## IV

We may sum up these paragraphs in the statement that science is defined by its point of view. The scientific man looks out upon experience from a certain standpoint; sees and can see his world only under one aspect; and by this attitude, which he has taken up toward experience, is limited to a particular type of method and to a particular type of problem. To invite him from his "academic reserve," or to demand that he interest himself in "practical ends," is simply to bid him cease from scientific activity. The scientific man, again, is logical, just as the historian or the jurist is logical; but logic is not science; and within science the facts of observation take precedence, and logical methods are secondary. To say that science leads to, or suggests, some general 'interpretation' of things, is to say what may or may not be true; but the saying, in either case, transcends science itself and changes the man of science into the philosopher. It must, indeed, be acknowledged that science, despite the immensity of its scope and the multitudinous variety of its subject-matter, confines its followers within relatively narrow limits; the shadow of the three adjectives is always upon them; and it is just because science is thus narrower than life that the man of science, unless he be of a certain temperament, is tempted to transgress the limits, and to betake himself in the long run to philosophy —or to spiritism.

V

Over against science, now, stands what we have called technology. In a certain restricted meaning, this term—which we have so far employed without comment—is familiar enough; the greatly extended meaning which it is here to receive must be justified by the sequel. The word is used henceforth to cover, in the broadest way, the activities that are ordinarily and misleadingly referred to as "applied science"; such things, that is to say, as engineering and medicine, in all their branches; such things as scientific agriculture, and domestic science, and school hygiene, and industrial chemistry, and eugenics. All these disciplines have a common character, by which they are set off from science; for, if science is defined by its point of view, technology (in the new and wider sense) is defined by its end or goal. Technology thus has its own narrowness; it is held down to the pursuit of some particular practical end; but this narrowness is different from the limitation of science. The technologist may change his point of view as often as he likes; he will use any method that promises to be serviceable; he will attack any problem that rises in his path. The result is that a "system" of technology is likely to appear to the man of science a mixed medley of more or less unrelated knowledge, and that a pure science is likely to appear to the technologist an example of fine-spun and quite needless consistency. A text-book of engineering will range from sections on pure mathematics and pure mechanics to practical directions for the setting-up of instruments and the reading of indicator cards; and a system of medicine, in the same way, will skip from theory to practise and from practise back again to theory within the boundaries of a single paragraph.[2]

[2] Consider, for example, what is probably one of the last attempts to treat the whole of mechanical engineering in a single volume, Lineham's "Text-book" (1902); read and abstract Ch. IX., On Energy and the Transmission of Power to Machines: or consult any chapter of such a work as Thompson's "Practical Medicine." Reading of this sort is instructive, not only to the man of science, but also to the technologist whose interests lie in other fields than those covered by the book under examination. When the engineer or the physician has been shown that the eugenist derives his materials from pathology and medicine, from

The authors are entirely in the right; their readers are physicians and engineers, and not physiologists and physicists; their subject-matter is held together and unified by a practical aim, and not by an initial point of view; it is unfair to judge them by the standards of science. A text-book of physics or of physiology, on the other hand, is—as we have seen—a transcription of the world of experience from a particular standpoint, which is deliberately adopted at the outset and deliberately maintained to the end; no item of experience that is not visible from this standpoint can properly get into it; and it is unfair to judge it by the needs and aims of a technology. All human activities have their limitations: and if the technologist is less clearly conscious of the restriction laid upon him by his practical end, and the man of science feels more keenly the narrowing of his universe by the scientific point of view,—the rule is certainly not without exceptions; but we may grant the tendency,—that is due partly to the greater outward diversity of the technological career, and partly to the more rigorous training in logic that scientific investigation affords and demands. The technologist never, to be sure, handles experience in its totality, but he deals with individual cases, and so comes nearer to the concrete than his scientific colleague; and he may, moreover, change from the practical to the scientific or the appreciative attitude without any great fear of leaving his last; his interests are thus diversified. The man of science, constantly applying the principles of logic, and constantly on his guard against the encroachment of logical theory upon the facts of observation, is forced to be self-critical, and so comes nearer to a true perspective.[3]

physical and social anthropology and ethnology, from statistics, from general biology, zoology, botany, thremmatology, from psychology and psychophysics, from ethics, economics, sociology,—then he is the more apt to realize from how many and how various sources his own discipline is sprung.

[3] A good illustration of what is here meant is furnished by the current use of the word "dynamic," to which attention has been called in the introduction. Occasionally, "dynamic" as opposed to "static" seems to mean simply temporal as opposed to spatial, or to imply a longitudinal section of experience as opposed to a cross-section. Ordinarily, however, as the term is used in psychiatry and "applied psychology," it seems to go back to an exploded theory of causation, or even behind causation to animism; it seems to imply a driving power, or motive force, or an interplay of effective powers and forces, such as is wholly unfamiliar to modern science. It has become, so far as the writer can make out, a sort of watchword, expressive of emotion rather than of thought; at any rate, he knows of no attempt to define it. Again, one of our leading psychiatrists warns the "professional psychologist . . . [to] come to the hospital clinic. He must imitate the geologist and leave his academic shades and seek his material for study where it is to be found. It is in pathologic conditions of the mind that he will find his true field of research." All honor to the clinic!—but has then the crust of our earth gone moldy, and are all geological formations diseased?

Different, however, as science and technology may be, they are also closely related. Technology draws on many other than scientific sources; it draws upon common sense, upon existing technologies, upon pre-scientific practise; but it draws continually upon science. Science, in its turn, is furthered by technology. The pursuit of a practical end often reveals some defect of theoretical knowledge; and the repairing of this defect, itself a contribution to science, may perform more than it promised, may in fact open up some wholly new field of scientific enquiry. That is the nature of the relation; and at first sight the advantage seems to lie with technology; for if the technologist needs the aid of science, he also appears capable of supplying for himself the science that he needs; he has only, for a little while, to shift his attitude, and the science is forthcoming. Where, then, would be the loss if pure science, with its "unreal" and "abstract" concerns, went by the board, and we all became practical together?

In answer to this question there are two things to be said. We must remember, in the first place, that every technology is limited by its end. When a technological need suggests a problem in pure science, the suggestion bears directly upon the need out of which it arises, and upon that need only; when the need is satisfied, there is no further sanction, within the technology, for purely scientific work. If, in other words, the progress of science were made dependent upon the progress of technology, and theory were never invoked save for the sake of practise,—if such a state of things were conceivable,—then our scientific knowledge would perforce remain scrappy and partial, so scrappy and so partial that a halt would ultimately be called to the advance of technology itself. An all-embracing technology, starting out with things as they are to-day, would no doubt be able to maintain itself for a relatively long time; theory is, in general, so far ahead of practise that, though science now stopped short, technological advance would long be possible. It is this fact, of course, which gives a plausible coloring to the demand that science leave its heights and come down among "every-day people," and that the man of science, instead of adding to his store of observed facts, use his scientific capital for "practical" and "vital" purposes. Sooner or later, however, the capital would be exhausted; sooner or later, progress would slow down to stagnation; the needs of technology, occasional needs of a circumscribed activity, would not suffice in the long run for the advancement of science. And then there is the other side of the shield! Technology, we said, draws from many sources, but is continually drawing upon science; each separate technology, we may here add, upon many sciences. Now if any induction from the history of human achievement is secure, it is surely this: that there is nothing in science so abstract, or so remote from matter of fact, or so indifferent to common sense, that it may not, some day or other, prove of service to a technology; and since this is the case, it is really to the interest even of the most practical man that scientific activity should be conserved and encouraged.[4]

A second consideration brings us by a different road to the same conclusion. The close relationship that we have shown to hold between science and technology is the relationship that holds in a scientific age,—at a time when science has won to recognition, is cultivated internationally, is widely popularized. In such an age, it is natural, as it is also the best policy, for technology to draw upon science. Technological activity, however, is a very complicated affair; and it may be doubted whether technology, if left wholly to itself, would turn instinctively even to the best scientific systems available; still more that it would supply for itself, by arduous and unaccustomed work, the knowledge that those systems fail to furnish. The tendency would rather be (and this is no dispraise to the technologist, who may never lose sight of his practical end) to fall back upon past science, upon science that was already more or less familiar, or to extend technological activity by purely technological means. Indeed, this tendency may be observed at the present day. The leader of a reform-movement in psychiatry, which has found critics and adherents over the whole civilized world, expressly bases his teaching upon psychology; but the psychology which he has in part adopted, in part worked out anew,—and which he appears to find entirely adequate to his technological needs,—is in essentials the psychology of a past generation. The writer takes this illustration from the field which is most familiar to him; the reader will be able to supply others from his own experience. The moral of such things is surely plain: that the technologist, for the very sake of his technology, needs the stimulus, the criticism and the assistance, of the man of science. Practical work tends, always and everywhere, to become routine work; routine tends toward conservatism, toward the defence of the old and the avoidance of the new; and conservatism ensures social stability. But if our ideal of society is a progressive equilibration, rather than the mere inertia of routine, then the conservatism of practical work must be tempered by the radicalism of science.

## VI

It is difficult, in writing upon a disputed question, not to give the impression that one is trying to disparage one's opponents. Yet the writer has no desire, despite the many hard things that technologists have said of the science with which he is most nearly concerned, to attempt any sort of disparagement of technology. Science and tech-

[4] "The fact is"—so Clifford puts the matter—"that the most useful parts of science have been investigated for the sake of truth, and not for their usefulness."

nology are, first of all, different. Science is defined by its point of view; the man of science takes his stand at the handle of the fan, and looks out along the sticks to an undefined periphery. Technology is defined by its practical end; the technologist, moving over the periphery, chooses and shapes the sticks which are to meet at the pivot that he has always held in view. The advice to "let the facts lead us where they will, over the hills and dales of physiology, into the deep borings of anatomy, or upward into the ethereal reaches of psychology" is admirable advice to offer the technologist; but its phrasing shows that it would be fatal if accepted by the man of science. For suppose that the man of science should accept it! Then the technologist, asking physiology for a detail of the landscape, might receive a sample of ore; or asking anatomy for the dip of the strata, might receive a cloud-photograph: things well enough in their own place but, out of place, turning his ignorance into sheer confusion. It is only in so far as he can rely upon the physiologist to keep his physiological point of view, and the psychologist his psychological, that the technologist is able to move freely from the one science to the other in pursuit of his practical end.

It follows from this primary difference that no technology is properly characterized as the application of a special science. Every technology is itself a special discipline, indebted (to be sure) to many sciences and to many other sources than science, but adding matter and method of its own, and rounding up all that it handles into a single whole. It is therefore no more in order to speak to-day, say, of an "applied psychology," than it would be to call engineering by its older name of "applied mechanics": and the sooner we recognize that, in this particular sense, technology is independent of science, that the technologist lives and moves in a world of his own, has his own problems and methods, is charged with a special message to his generation, the sooner shall we exchange our present bickering for the harmony that we desire.

Science and technology are, in the second place, closely related; the nature of the relationship has been sketched in preceding paragraphs. If we look at this relation from without, from the side of maintenance and material aids, then the advantage lies with technology, and science is the beneficiary. The scientific man, accordingly, should rejoice at every technological advance, seeing that it ensures by just so much the material future of science. "How many men," asked Kepler in the old time, "how many men would be able to make astronomy their business, if men did not cherish the hope to read the future in the skies?"—and, with change of terms, the story is told again of us moderns. If, contrariwise, we look at the relation from within, then, as this paper has tried to show, technology appears as the beneficiary of science. The technologist should accordingly rejoice at every scientific advance, seeing that it means just so much more of observed fact which he may some day utilize in his practise. To slight the "leisure-class problems of true science" in the supposed interest of activities which "earn their bread in terms of usefulness for the questions of life" is really to mistake that interest, and to wound technology in the house of its friends.

Lastly, science and technology are alike in their free recourse to the established laws and approved methods of logic. Science is, on the whole, more rigorous than technology in this logical regard; not through any superior virtue in the man of science, but simply because the technologist, in the nature of the case, is a logical opportunist, working for results and towards a practical end, and therefore content to work in a logical twilight so long as results are forthcoming and progress can be reported. That the technologist should, on occasion, betray impatience with the stricter canons of scientific procedure is only natural. That the student of science should stir in his own defence must also be expected: how great, after all, are the benefits that science has conferred upon humanity! What we may hope for is that men of intelligence and sound training, after they have been distributed by temperament or circumstance to scientific and technological activities, may still so far keep in touch that each understands the other's limitations and sympathizes with the other's ideals.

# THE ILLINOIS SYSTEM OF PERMANENT FERTILITY

By Professor CYRIL G. HOPKINS

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I HAVE been invited to write upon the Illinois system of permanent fertility; but I wish to state in the beginning that, in complying with this request, I am speaking in a representative capacity. Many have contributed to the development of this system, including both able investigators in other states and countries, my own colleagues in the investigation of Illinois soils, and the truly scientific farmers of this state, some of whom have kept their own farm practise so close up to the work of the experiment stations as to exert great influence upon the adoption of systems of permanent fertility.

It is more than fifty years since Liebig wrote the following words:

> Agriculture is, of all industrial pursuits, the richest in facts, and the poorest in their comprehension. Facts are like grains of sand which are moved by the wind, but principles are the same grains cemented into rocks.

An important part of the work performed in Illinois has consisted in assembling the facts the world affords and cementing these into concrete forms which serve as a firm foundation upon which to build systems of permanent agriculture.

The main problem of permanent fertility is simple. It consists, in a word, in making sure that every essential element of plant food is continuously provided to meet the needs of maximum crops; and, of course, any elements which are not so provided by nature must be provided by man. The whole subject has been greatly and unnecessarily complicated, not only by erroneous theories commonly held by farmers and something advocated by unscientific "scientists" holding official positions, such as the theory that crop rotation will maintain the fertility of the soil, but also by the ruinous policy of most commercial fertilizer interests in urging and often persuading farmers to use small amounts of high-priced so-called "complete" fertilizers which add to the soil only a fraction of the plant food actually required by the crops removed, with the inevitable result that the land itself is steadily impoverished.

The more rational system makes use of abundant quantities of all essentials, but at a cost low enough to be within reasonable reach. Those materials which are naturally contained in the soil in inexhaustible amounts are liberated from the soil and thus made available for crop production; those contained in the air are likewise drawn upon as needed; while those materials which must be purchased are bought and applied in liberal quantities, but in low-priced forms, and then made available on the farm by economic natural methods.

### Four Fundamental Facts

Nearly 150 years ago Sénébier, of Switzerland, found that the carbon of plants is derived from the carbon dioxid of the air, and it is more than a century since DeSaussure, of France, first gave to the world a correct and almost complete statement concerning the essential mineral food of plants. Later, Lawes and Gilbert, of England, established the fact that for most plants the soil must furnish the nitrogen as well as the mineral elements; and more than a quarter-century has passed since Hellriegel, of Germany, discovered that bacteria living in symbiotic relationship with legume plants have power to gather nitrogen from the inexhaustible atmospheric supply.

These are the four great fundamental facts upon which the science of plant growth and permanent fertility must be based, and they were all discovered before the Illinois Experiment Station was established.

### Illinois Contributions

There remained, however, two very important general problems, and in the solution of these Illinois has made some contributions. One of these relates to the amount of nitrogen taken from the air by legumes under normal field conditions; and the other concerns the liberation of mineral plant food from insoluble materials.

It is not enough to know that clover has power to secure nitrogen from the air; we should know how much nitrogen is thus secured in order that we may plan intelligently to provide nitrogen for the production of corn, oats, wheat and other non-legumes, instead of using clover merely as a soil stimulant in systems of ultimate land ruin, as is still the most common practise.

It is also a matter of the greatest economic importance that definite information should be secured in regard to the practical means of utilizing mineral plant food from the abundant natural supplies nearest at hand, such as Tennessee phosphate rock, natural limestone, and the potassium minerals already present in our normal soils.

### Plant-food Elements

In brief, there are ten elementary substances which bear the same relation to the making of crops as brick and mortar bear to a wall of masonry. If any one of these ten elements is entirely lacking, it is impossible to produce a grain of corn or wheat, a spear of grass, or a leaf of clover.

Two elements, carbon and oxygen, are taken into the plant from the air through the leaves; hydrogen is secured from water absorbed by the roots, and iron and sulphur are also supplied by nature in abundance.

But the other five elements require careful consideration if lands are to be kept fertile. These are potassium, magnesium, calcium, phosphorus and nitrogen; and every landowner ought to be as well acquainted with these five elements as he is with his five nearest neighbors.

Instead of making this acquaintance and gaining a knowledge of important facts and principles, the average farmer in the older states, with failing fertility, has made the acquaintance of the fertilizer agent; and instead of purchasing what he needs for the permanent improvement of his soil, he buys what the agent wants to sell, with the common result that the seller is enriched while the soil is merely stimulated to greater poverty.

*Potassium.*—A careful study of the facts shows that potassium is one of the abundant elements in nature; that the average crust of the earth contains $2\frac{1}{2}$ per cent. of this element, and that normal soils bear some relation in composition to the average of the earth's crust.

If normal soil had the same percentage, then the plowed soil of an acre $6\frac{2}{3}$ inches deep (corresponding to 2 million pounds of soil) would contain 50,000 pounds of potassium. In Illinois, the normal soils actually do contain from 25,000 to 45,000 pounds per acre of this plant-food element in the first $6\frac{2}{3}$ inches, while less than 4 pounds of potassium would be added in an application of 200 pounds of the most common commercial fertilizer. The Illinois system of permanent fertility does not provide for the purchase of potassium for normal soils, but it does provide for the liberation of an abundance of that element from the practically inexhaustible supply in the soil. This liberation is accomplished by the action of decaying organic matter plowed under in the form of farm manure or crop residues, including clover or other legumes.

Only where the soil is positively deficient in potassium susceptible of liberation, as is the case with some sand soils and with most peaty swamp lands, need potassium be purchased in permanent systems of either grain farming or live-stock farming; but in market gardening or in raising timothy hay for the market commercial potassium may be required; and, on some worn soils especially deficient in decaying matter, temporary use of kainit is often advisable.

*Magnesium and Calcium.*—As a general average, normal soils contain more than four times as much potassium as magnesium, while the loss by leaching and cropping in rational systems of grain or live-stock farming may be actually greater for magnesium than for potassium, so that magnesium is more likely to become deficient in soils than is potassium.

The calcium supply in normal soils is also only one fourth that of potassium, while the average loss by cropping and leaching is four times as great, so that 16 to 1 expresses the relative importance of calcium and potassium in the problem of permanent fertility on normal soils.

All limestones contain calcium; and the common dolomitic limestone in the almost measureless deposits contains both calcium and magnesium in very suitable form both for plant food and for correcting or preventing soil acidity.

In the Illinois system of permanent fertility, ground natural limestone is applied, where needed, at the rate of about two tons per acre every four years. With the same price and purity, probably the dolomite is preferable to the high calcium stone, although both kinds have been used with very good results. Further data from investigations now in progress are expected to furnish definite information as to the relative value of these materials.

*Phosphorus.*—Attention was called to the fact that two million pounds of the average crust of the earth contains 50,000 pounds of potassium; but compared with this we find only 2,000 pounds of phosphorus. Likewise, the plowed soil of an acre of average Illinois land contains about 35,000 pounds of potassium, but less than 1,200 pounds of phosphorus. When grain is sold from the farm, about equal amounts of phosphorus and potassium are carried away, while in independent systems of live-stock farming much more phosphorus than potassium leaves the farm.

At 3 cents a pound for phosphorus one can double the amount of that element contained in the plowed soil of our $200 land at a cost of $35 an acre, while to double the potassium in the same stratum would cost more than $1,000 an acre.

Phosphorus can be purchased, delivered at the farmer's railroad station in Illinois, for about 3 cents a pound in the form of fine-ground natural rock phosphate, for 10 to 12 cents a pound in steamed bone meal, or for 12 to 15 cents in acid phosphate. It can be used with profit in any of these forms, but the data thus far secured in comparative experiments plainly indicate that, with equal amounts of money invested, the natural rock phosphate will give the greatest profit in rational permanent systems. At least 1,000 pounds per acre every four years should be applied, and for the first application even three or four tons per acre is not considered too much phosphate by those who best understand the need and value of phosphorus on normal land.

*Nitrogen and Organic Matter.*—There is a rather common opinion that the growing of clover enriches the soil in nitrogen, and many even believe that clover in crop rotation will maintain the fertility of the soil. These same people are likely to think that the application of limestone and phosphate involves much expense and work, and that the returns are much less certain than those from other labor and money investments.

Such opinions are largely erroneous. The mere growing of clover on normal land does not enrich it. Even the nitrogen is not increased unless the clover crop is returned to the soil either directly or in farm manure. Rotation with such crops as corn, oats and clover depletes the soil of all important elements of fertility, and on normal soils always results ultimately in land ruin, unless some system of restoration is practised. Clover takes large amounts of calcium and phosphorus from the soil, and does not increase the nitrogen content if only the roots and stubble are left, because they contain no more nitrogen than the clover itself will take from soils of normal productive power.

To increase or maintain the nitrogen and organic matter of the soil is the greatest practical problem in American agriculture. In an hour's time one can spread enough limestone or phosphate on an acre of land to provide for large crops of wheat, corn, oats and clover for ten or twenty years, while to supply the nitrogen for the same length of time would require from 20 to 40 tons of clover, or from 80 to 160 tons of farm manure, to be added to the same acre of land, even though one of the four crops harvested secured its nitrogen from the air.

Certainly we are making no such additions to the soil in average corn-belt agriculture, and one may well ask, How then is it possible to grow the crops now produced in this country? In the simplest language the answer to this question is: By "skinning" the soil—by working the land for all that's in it—by following the example of our ancestors, who brought agricultural ruin to millions of acres of once fertile farm land in the original thirteen states.

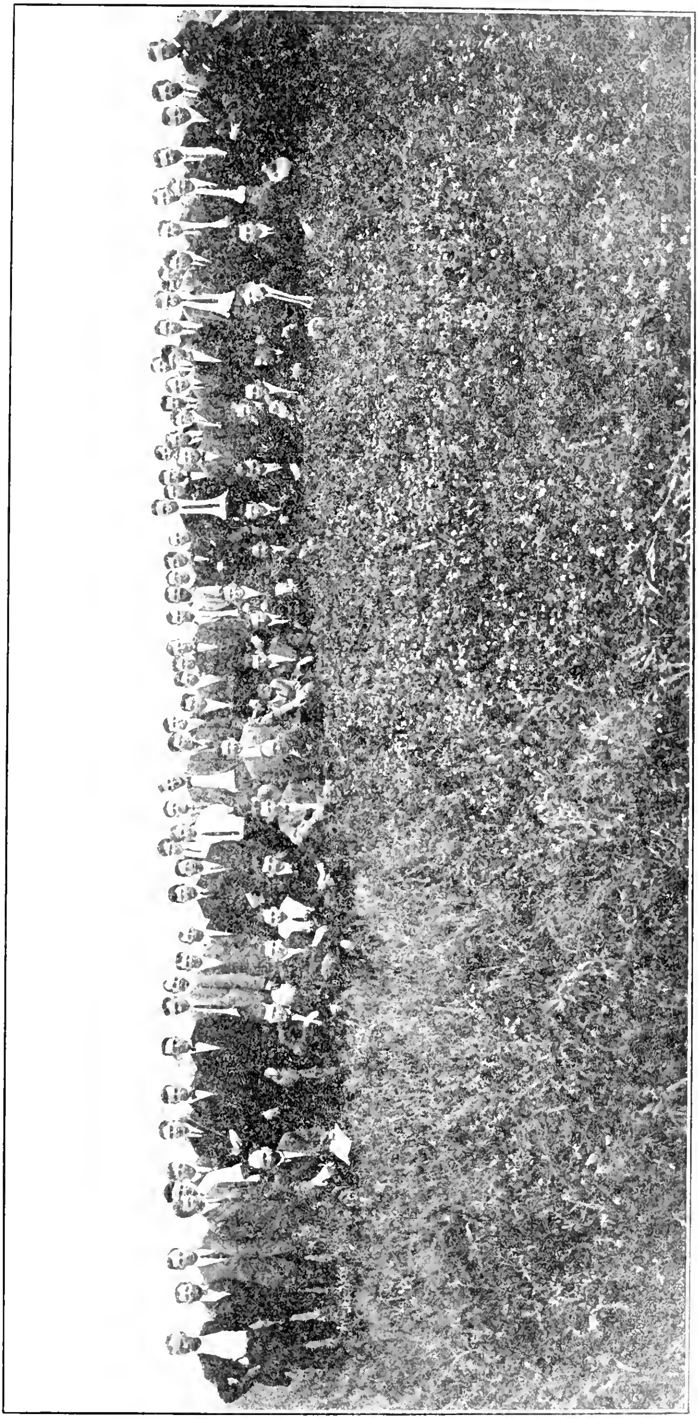
To provide nitrogen in the Illinois system of permanent agriculture requires the use of common sense and positive knowledge, the same as in providing limestone and phosphorus.

For the live-stock farmer I would suggest a five-field system—a four-year rotation of corn, corn, oats and clover, grown upon four fields for five years, while the fifth field is kept in alfalfa. At the end of the fifth year the alfalfa field is brought into the rotation and one of the four fields seeded to alfalfa for another five-year period, and so on.

If the crop yields are 50 bushels each of corn and oats, 2 tons of clover and 3 tons of alfalfa; if the straw and half the corn stalks are used for bedding and all other produce for feed, and if 60 per cent. of the nitrogen in the manure is used for the production of crops, then a system is provided which will permanently maintain the supply of nitrogen.

For the farmer who sells grain, a 25-bushel wheat crop may well be substituted for the first corn crop, clover being seeded on the wheat for plowing under next year before planting corn. If the fall and spring growths of this clover aggregate 1½ tons, and if only the grain and clover seed and the alfalfa hay are sold, all clover, stalks and straw being turned to the land, this also provides a system for the permanent maintenance of nitrogen.

If the crop yields are all increased by 50 per cent., or even by 100 per cent., these systems still provide for the nitrogen supply, unless with the larger yields on richer land a somewhat greater amount is likely to



Class Inspecting Poorland Farm. Clover, 1912. Check strip on the left. Treated land on the right.

be lost by leaching than is added in the rain and by the azotobacter and other non-symbiotic bacteria.

While these systems are distinctly for live-stock farming or for grain and hay farming, they should be considered as only suggesting the basis for solving the nitrogen problem. In diversified farming a combination of these systems will often be preferred to either one alone. The important point is that the landowner should know the essential facts and base his practise upon them in order to provide for permanent fertility with respect to nitrogen, phosphorus and limestone.

### Application of Principles Established

*Louisiana Experiments.*—The longest record of a rational permanent system of agriculture conducted in America is furnished by the Louisiana Experiment Station. As an average of nineteen years, the values per acre of three crops were $29.79 from unfertilized land, and $92.04 where organic manures and phosphorus were regularly applied[1] in a three-year rotation of (1) cotton, (2) corn and cowpeas, (3) oats and cowpeas. Here the crop values from the well-fertilized land average more than three times as great as those from the unfertilized land under the same rotation and with two legume cover crops grown every three years.

*Ohio Experiments.*—The Ohio Experiment Station has reported sixteen years' results from a three-year rotation of corn, wheat and clover, both from unfertilized land and from land treated with farm manure and phosphorus. As a general average, the values per acre of the three crops at conservative prices were $27.07 on untreated[2] land, $44.65 where farm manure was applied, $53.82 where manure and rock phosphate were used, and $53.61 where manure and acid phosphate were applied, practically the same yields having been secured whether the phosphorus was applied in raw rock phosphate or in acid phosphate, costing twice as much. The well-fertilized land has produced nearly twice as much as the land where no manure and phosphate were used, although clover was grown every third year in the rotation and all of the land was limed.

On the basis of these figures, 8 tons of manure were worth $17.58, or $2.20 per ton; and the rock phosphate, costing about $7.50 or $8 per ton, was worth $57.31; or, if we use the Ohio methods of computing the amount and value of the increase produced, each ton of raw phosphate was worth $65.63; and it may well be added that to obtain the same amount of phosphorus in the common high-priced mixed manufactured commercial fertilizer, such as farmers are advised by the

[1] In addition, five pounds per acre of potassium were applied every three years.

[2] Except for lime and clover.

POORLAND FARM: Clover and timothy, 1913. Check strip.

fertilizer manufacturers and advertising agencies to use, would cost about $75.

*Illinois Experiments.*—As an average of 318 tests conducted in southern Illinois during a period of eight years, two tons of ground limestone, applied once in four years at a cost of about $2.50 per acre, has produced an increase of 5 bushels of corn, 6½ bushels of oats, 4 bushels of wheat and ½ ton of hay; and where one ton per acre of fine-ground rock phosphate was applied on the common corn-belt land in a rotation of wheat, corn, oats and clover, the value of the increase produce paid back more than 100 per cent. for the first crop rotation and nearly 200 per cent. for the second four-year period.

On one of our oldest soil experiment fields on typical Illinois prairie


POORLAND FARM: Clover and timothy, 1913. Regular treatment.

land, where soil enrichment has been practised for twelve years, during the last four years the value of the produce from the land receiving phosphorus has been twice as much as that from the untreated land. In other words, $2.50 invested in phosphorus has brought the same gross income as $250 invested in land; and even the interest on the land investment is five times the annual cost of the phosphorus. Furthermore, the addition of phosphorus tends toward enrichment and consequently toward the protection of the capital invested in the land.

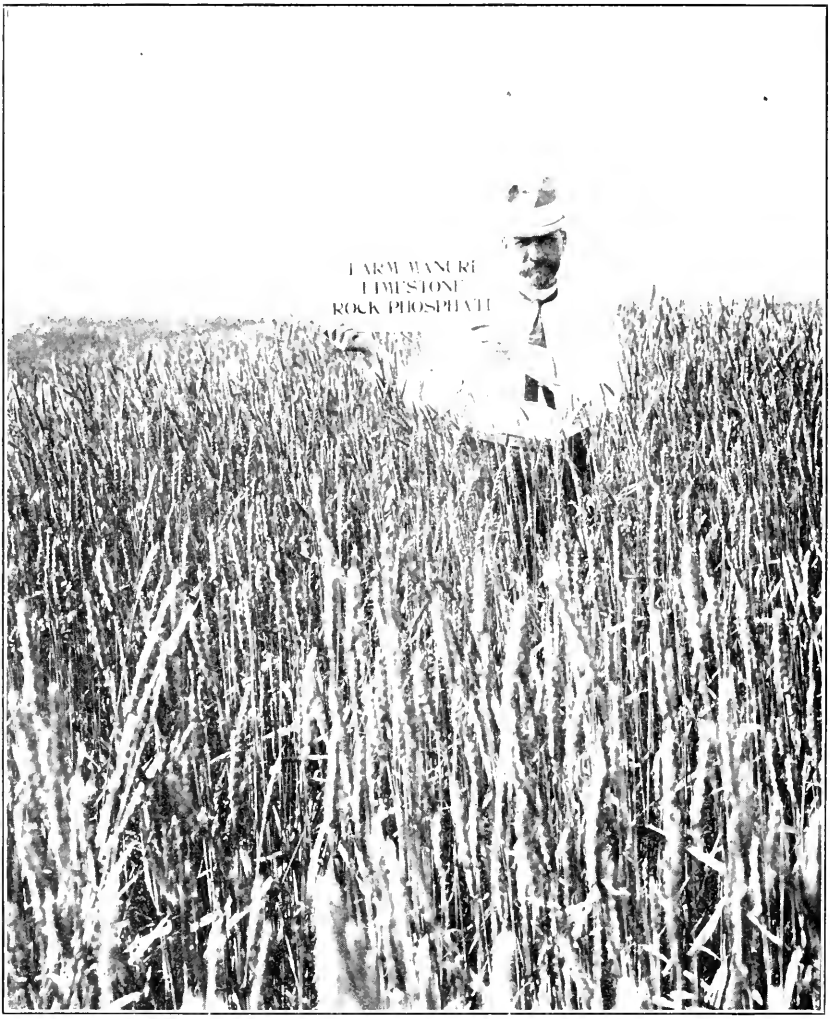
It is sometimes suggested by people who have no intelligent basis for such an opinion, that the result secured by an experiment station upon relatively small tracts of land could not be secured in practical agriculture. In part to disprove such incorrect and unjust statements,


POORLAND FARM: Wheat, 1913. Check strip, 11½ bushels per acre.

I purchased a farm in southern Illinois ten years ago at a cost of less than $20 an acre. It comprised about 300 acres of poor gray prairie land (the commonest type of soil in about twenty counties in that part of the state) and a few acres of timber land. It was christened "Poorland Farm" by others who knew of its impoverished condition.

In 1913 a 40-acre field of this farm produced 1,320 bushels of wheat. This particular forty acres was bought at $15 an acre. It had been agriculturally abandoned for five years prior to 1904, and was covered with a scant growth of red sorrel, poverty grass and weeds.

During the ten years this field has been cropped with a rotation including one year each of corn, oats (or cowpeas) and wheat, and three




Poorland Farm: Wheat, 1913. Regular treatment, 35½ bushels per acre.

years of meadow and pasture with clover and timothy. About 4 tons per acre of ground limestone and 2 tons per acre of fine-ground raw rock phosphate have been applied to 37 acres of this field. Two applications have been made of each material; the phosphate was plowed down for the corn crops of 1904 and 1910, and the limestone was applied in the fall and winter of 1904–5 and after the ground was plowed for wheat in the fall of 1912.

The entire 40-acre field was covered with one uniform application of six loads per acre of farm manure with a 50-bushel spreader.

A six-rod strip entirely across the field (80 rods) received the same application of manure and the same rotation of crops as the remaining 37 acres, but no phosphate was applied to this strip, and no limestone was applied to it until the fall of 1912, when the regular application (about 2 tons per acre) was applied to one half (three rods) of the six-rod strip.

Only 39 acres of this field were seeded to wheat in the fall of 1912, a lane having been fenced off on one side; and the 1,320 bushels were produced on the 39 acres.

The actual yields were as follows:

1½ acres with farm manure alone produced 11½ bushels per acre.

1½ acres with farm manure and the one application of ground limestone produced 15 bushels per acre.

36 acres with farm manure and two applications of ground limestone and two of fine-ground phosphate produced 35½ bushels per acre.

The cost of two tons of limestone delivered at my railroad station is $2.25, and raw rock phosphate has averaged about $6.75 per ton, making $9 per acre the cost for each six years.

To this must be added the expense of hauling these materials two miles from the station and spreading them on the land, which I estimate at 50 cents per ton. This makes the average annual cost $1.75 per acre for the limestone and phosphate spread on the field, and this average annual investment resulted in the increase of 24 bushels of wheat per acre in 1913.

Thus we may say that the previous applications of these two natural stones in this system of farming brought about the production in 1913 of 864 bushels of wheat, sufficient to furnish a year's supply of bread for more than a hundred people. And the soil is not being stimulated or depleted of any element in which it is naturally deficient. On the contrary, there is positive soil enrichment; "new" nitrogen is secured from the air, the phosphorus content has already been increased to that of the $200 corn-belt land, and sour land is changed to a "limestone soil." No high-priced or artificial commercial fertilizers are used on this farm; and the results secured from 40-acre fields on a 300-acre farm are practically the same as on the one fifth-acre plots of the state experiment fields under similar systems.

Poorland Farm is usually inspected each year by my class of university students in soil fertility, about one hundred of whom saw the fields of wheat and clover in June, 1913. It is for the benefit of such as these, who desire to know the truth regarding economic systems of permanent soil improvement, that this brief statement is published.

# CHABANEAU: AN EARLY WORKER ON PLATINUM

By Professor JAS. LEWIS HOWE
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NOT long since M. Louis Quennessen of Paris (head of the old house of Des Montis & Co., platinum refiners) directed my attention to an early worker on platinum, Pierre-François Chabaneau, whose name has so far escaped the historians of chemistry that I think it is not even mentioned in any English or German work, and has only appeared in the last edition of Moissan's "Traité de Chimie Minèrale." More recently, through the courtesy of M. Quennessen, I have received a copy of an all but unknown memoir, "Notice sur Chabaneau, Chimiste Périgourdin," par M. Jules Delanoue, printed at Périgueux in 1862, portions of which appear to be of sufficient interest to put on record. This biographical sketch was written in 1857, though not published till five years later, and has for its purpose "to call to the attention of our citizens the useful work, too little known, of a modest man, who unquestionably deserves the first place among the distinguished men whom Périgord has given to the world."

It may be noted that Périgueux is the capital of the old province of Périgord (now in part Dordogne) in southwest France, and has an interesting history going back to the time when it was the old Gallic town of Vesunna, the capital of the Petrocorii. Numerous remains of Vesunna are still in existence, especially baths, temples, an aqueduct and fragments of the amphitheater, mostly dating from its Roman occupation. The most notable building of Périgueux is the cathedral of St. Front, belonging to the Byzantine period, which bears quite a close resemblance to St. Mark's at Venice. The town has undergone many vicissitudes, having been taken by the barbarians in the fourth century, the Saracens in the eighth, the Normans in the ninth, the English in the fourteenth, and later restored to the French. It was a stronghold of the Calvinists in the Huguenot wars, and at this time was nearly laid in ruins. In the midst of an agricultural region, it is perhaps best known for its truffles and chestnut-fed hogs, the latter being used in hunting for the former.

The early history of Chabaneau is a not unfamiliar one of precocity and hardship.

> Pierre-François Chabaneau was born at Nontron (in northwestern Dordogne) April 21, 1754. His family were respectable artisans, and he would undoubtedly have followed the obscure career of his parents, had not his intelligence and pronounced love of study attracted the attention of his uncle, a

monk of the order of St. Antony, at Aveyron (in south-central France, a hundred or so miles from Nontron). Young Chabaneau spent several years with this uncle, pursuing his studies along ecclesiastical lines, destined for the church. He was then sent to Paris for further theological study with the Oratorians, for his uncle was evidently by no means an ascetic. Here, for the sake of his kinsman, he entered upon his studies with great ardor and made such rapid progress that he astonished his teachers; his theses were the admiration of all. Nevertheless, in spite of his brilliant successes, other influences were working on him, as is so often the case with such natures. He was not born for metaphysical studies; his inquiring disposition could not accommodate itself to the abstractions of scholastic philosophy. The unsupported scaffolding of theological hypotheses, the interminable verbiage, the halting arguments of the doctors, all failed to satisfy the spirt of the young Chabaneau and to accord with his ideas. He demanded mathematical arguments, the definiteness of figures, exact science, and not the science of paradoxes; his reason rebelled at the false ideas they sought to teach him. In his dissertations he refuted his teachers by arguments which they could not controvert, and did it so thoroughly that the furious professors finally expelled their audacious scholar, as a punishment for his independence and for his success.

Behold now our young man in the streets of Paris, in the midst of the immense Babylon, without relatives, without friends, having neither experience of the world nor yet money! The six livres, which represented his whole fortune, had been expended in the purchase of a perruque, imperiously demanded by the customs of the times. He dared not return to his angry uncle, nor indeed had he the means for the journey. A kind Providence directed him to the abbé La Rose, to whom he related his story and revealed the extreme embarrassment in which he found himself. The worthy abbé was greatly interested and offered to place him as professor of mathematics in the Jesuit college at Passy (just out of Paris), of which he was the director. The young theologian, whose studies had been confined to Greek, Latin and philosophy, was absolutely unacquainted even with arithmetic. He was greatly disappointed when he learned what his employment would be, but necessity compelled him to seize even this plank of safety; it was this or nothing. He unhesitatingly accepted the position, without venturing to acknowledge his complete ignorance of the subject he was to teach; he thought that perhaps by work and perseverance he might be able to fulfil his duties. He gave proof on this occasion of energy rare in one of his age, for he was only seventeen.

It is related of Jacques Amyot, the celebrated translator of Plutarch, that while he was a college servant, he was possessed of such a desire for knowledge, that he studied at night by the light of the fire. Young Chabaneau, whom chance and want compelled to teach others what he did not know himself, and who had great ambition to worthily carry out his task, passed the nights in preparation of the lessons for the following day. He hid his lamp, and then, when all the college world slept, lit it and worked till day. And so it was that, with indefatigable labor, aided by a powerful physical constitution, he made himself master of arithmetic, algebra and geometry. Nor did he stop with these studies; the passion for knowledge dominated him. He studied experimental physics, natural history and chemistry, that prodigious science which had just begun to give promise of the astounding wonders which have been realized in our day.

Just at this time was beginning the most active period in the work of Lavoisier, and it was the year before that he had presented to the Académie des Sciences his refutation of the supposed transformation of water into earth, in which the balance was used as an instrument of chemical research, and which soon led to the conception of the permanence of matter and later to the overthrow of the phlogiston theory. This work of Lavoisier could not fail to make a great impression upon such a mind as that of Chabaneau.

His pupils made rapid progress; they wondered at the knowledge of the young professor, and the director, abbé La Rose, did not cease from expressing his satisfaction. . . .

Chabaneau was now about twenty years old, an age when is often born the love of independence. He knew that the knowledge which he now possessed would suffice to supply all his material needs. He therefore resigned from his position in the college of Passy, after having expressed his most sincere thanks to his benefactor, and, taking lodgings in the Rue des Mathurins, within the city, opened after the fashion of that day a course of public lectures which met with great success.

Among the most assiduous of his auditors were the young sons of the Comte de Pena-Florida, whose father had sent them to France to complete their education, and also to procure several professors for a great college for the nobility which he purposed founding at Bergara.

Bergara was a small city in the Basque province of Guipúzcoa in northern Spain, and near the bay of Biscay. It afterwards came into some prominence as the place where the treaty was signed in 1839 between Spain and the Carlists of the Basque provinces. Of the subsequent history of the college I have been able to learn nothing.

The young nobles gained the affection of their professor and made him the most brilliant offers if he would accept the direction of the college founded by their father. For a long time Chabaneau resisted, but, finally yielding to the earnest solicitation of the young marquesses and other friends, he decided to exchange France for Spain. He immediately began the study of the Spanish language, and with such ardor that in a few months he felt that he had fully mastered it.

He remained three years at Bergara, devoted himself without relaxation to scientific study, and acquired such a reputation that the king, Charles III., wishing to locate him in Madrid, created for him a public Chair of Mineralogy, Physics and Chemistry, lodged him in one of his palaces, and granted him an annual stipend of 2,200 piasters ($2,400), a very considerable sum for that time.

The inauguration of his course took place in the presence of the king and all the court. This opening lecture had for its subject the utility and the future of science, and was so remarkable that a Spanish poet composed for the occasion an ode, dedicated to the learned professor. Impelled by the love of science and wishing to justify the high favor in which he was held by the king, Chabaneau continued with great earnestness his scientific work. As he desired to enter into relations with all the learned men of Europe and to profit by their work, he recognized the necessity of studying English, Italian, German, etc. So energetic was he in his language study that at the age of twenty-five he was master of no less than eight languages, living or dead.

Charles III. provided Chabaneau with a valuable library and a laboratory, considered at that day "magnificent." All the spare moments remaining from his public instruction were devoted to the study of physics and especially of chemistry. At this period Spanish America was sending to the mint at Madrid not only ingots of gold and silver, but also from time to time a mineral in the form of little white metallic grains, infusible and very heavy. The miners found it associated with gold and with diamonds (?) and called it *platina,* from its similarity to silver (*plata* in Spanish).

The government had no use for the platina and, fearing it might be used to debase the coinage, ordered (ineffectually) that it should be buried when extracted from the ore. Meanwhile in 1741, an Englishman named Wood gave the knowledge of platina to Europe; in 1750 Watson announced that it contained a metal hitherto unknown; in 1752 Scheffer, director of the Stockholm mint, and in 1754 Lewis in London, dispelled all doubt regarding the fact that a new metal actually existed. Baron von Sickingen proposed a method for its extraction from the ore.

The new metal, platinum, thus obtained was in the form of a powder or sponge, which resisted fusion, even in the most powerful furnace, and was thus wholly useless in the arts. Chabaneau undertook the difficult task of obtaining platinum in metallic ingots, in spite of its infusibility. He recognized that this very infusibility would give great value to objects made of this new metal.

Several other chemists of the time had busied themselves with this same problem. The only hope of success appeared to be in alloying platinum with other metals, but this seemed to present insurmountable difficulties, owing in part to the impurity of the platinum ore, and also to the large amount of other metals necessary for its solution. It was early observed (von Sickingen says by Scheffer, who wrote in 1751) that a small amount of metallic arsenic caused platinum to fuse easily, but the ingot thus obtained was exceedingly brittle. Achard (1779) found that by heating this alloy for a long time at a high temperature the arsenic was gradually volatilized, leaving a mass of platinum in a malleable condition. While his communication to the Berlin Academy is entitled "Leichte Methode, Gefässe aus Platina zu bereiten," it was nearly ten years before practical application seems to have been made of the method, and though a letter appears in *Krells Annalen* in 1790 stating that platinum vessels can be bought cheaply of Jeanty in Paris, they were actually very rare and possibly never practically used until after the close of the century. Achard's method seems, however, to have been used industrially by Jeanty as late as 1820, though the method of Chabaneau, rediscovered by Knight and possibly independently by Cock also, came into general use in the first decade of the nineteenth century. The vessels made by Achard's method could never have been satisfactory, especially owing to the difficulty of completely removing the arsenic from the platinum.

Among the nobility who had interested themselves in the founding of the college at Bergara was the Marquess of Aranda. This man (minister of state and general, in 1787 ambassador to Paris) was distinguished among all the nobles for his devotion to science. He held Chabaneau in high esteem and encouraged him strongly in his projected work upon platinum. He had the government turn over its whole supply of platinum ore to Chabaneau, and furnished him everything in his power for the laborious undertaking, Laborious indeed, for even to-day Dumas says "of all analyses, that of platinum ore is, without contradiction, the most difficult."

In spite of the regal luxury of his laboratory, Chabaneau found at that time in Madrid fewer resources than would to-day be offered by the most unpretentious laboratory in France. Chabaneau was obliged to prepare his own reagents and make his apparatus. Chemistry was still an empiric science and Lavoisier had only just begun to bring order out of chaos. Further, at this time no one could have suspected that in addition to gold, mercury, lead, copper, iron, etc., the platinum ore contained five more metals, osmium, iridium, palladium, rhodium and ruthenium, not discovered till 1803 and 1844. Chabaneau found himself contending with six metals where he supposed there was only one, platinum. Inevitable mistakes and innumerable disappointments naturally resulted. He had proved that platinum was malleable, yet occasionally he found it despairingly brittle (this was an alloy with iridium); he knew that it was infusible, incombustible and unoxidizable, yet he was stupefied to see it at times burn and volatilize (this was the alloy with osmium).

The Marquess of Aranda, appreciating the great interest attaching to the industrial use of a metal of which Spain possessed all the mines, came often to Chabaneau's laboratory, and often found him discouraged and busying himself on other investigations. At such times Aranda, a most genial and lovable character, would console him, encourage him, and in the end bring him back to that which Aranda considered his great task, the investigation of "white gold," as it was then called. Chabaneau would take up with new zeal his tantalizing work, and so passed days and nights, months and years. At last he succeeded in surmounting all difficulties, his wearisome task was rewarded by the discovery of a process by which the metal could be purified. The effectiveness of the method was verified by several repetitions. The enchanted Marquess had him carry it out on a large scale and came to the laboratory each day with increasing interest. Judge of his astonishment and horror when one day he found Chabaneau in a frenzy engaged in throwing out the door and windows his dishes, flasks and ores, as well as all the solutions of platinum which he had prepared with so much trouble and difficulty.

The Castillian imperturbability of the Marquess only redoubled the French fury of the young chemist. "Away with it all. I'll smash the whole business," he cried in a mixture of French and the patois of Périgord. "You shall never again get me to touch the damned metal." And in fact he broke up all the apparatus of the laboratory.

Really this infantile fury was to some extent justifiable. No one knew then, and indeed few know now, that lime does not precipitate platinum in artificial light, but that in daylight the metal is completely precipitated by this reagent. Chabaneau, working with lime at night, had been enabled to precipitate all the other metals which were present in his solution, while his platinum was left unprecipitated and purified. Repeating the operation by day, platinum and all were thrown down, and he was completely at sea, without being able to suspect the reason.

Three months later, at the home of the Marquess of Aranda there appeared upon a table an ingot some ten centimeters cube, with a beautiful metallic luster; it was malleable platinum. The enthusiastic Marquess started to pick it up, but failed to move it. "You are joking," said he to Chabaneau, "you have fastened it down." "No indeed," said the professor, and he raised the little ingot easily, though it weighed some twenty-three kilograms. The Marquess had not thought that the light platinum sponge would thus appear as the heaviest of all (then known) metals.

Chabaneau's discovery consisted in compressing the platinum sponge while hot at the moment of its formation, and then hammering it several times while at a white heat. Since platinum is infusible at the highest temperature of a furnace, it is easily recognized how difficult it had been to convert the pulverulent metal into an ingot. This infusibility is, however, only relative, since Deville has since succeeded in fusing the metal with the oxygen-hydrogen blowpipe; but this property, added to a resistance to the action of acids equal to that of gold, evidently entitles platinum to rank with the precious (noble) metals.

It is to be noted that there were two necessary conditions for the preparation of malleable platinum, either of which was useless without the other. First, the metal must be obtained from the ore in a pure condition, for unless separated not only from the base metals, but also from the largest part of the other platinum metals, the sponge can not be welded into a malleable mass; second, while at a high temperature the sponge of pure platinum is easily compressed into a malleable ingot, at low temperatures it has no coherence. Virtually this process, generally attributed to Knight, was in use almost exclusively until the last third of the nineteenth century.

The king, who spent some of his leisure moments dabbling in science, often came to Chabaneau's laboratory and assisted in his experiments. He was very proud to have such a discovery made in his capital, and caused a commemorative medal to be struck in platinum. He also gave Chabaneau a life pension of 2,800 piasters ($3,000), in addition to his annual stipend of 12,000 livres, but the pension was granted only on the express condition of residence in Spain, and was to be forfeited should Chabaneau leave the kingdom. The letters-patent bear the date of 1783, and thus establish the priority of Chabaneau's discovery officially and in an incontestible manner.

Chabaneau was for some time engaged in preparing large quantities of malleable platinum. Then his patron, Marquess d'Aranda, having been appointed ambassador to France (1787), he was prevailed on to accompany him to Paris, in order to convert under his auspices some of the new metal into ornaments for the crown. Jeanetty, goldsmith to the court of France and a very able man, had been commissioned for this work, and he sought vainly to discover the process used by Chabaneau. He did, however, discover another method (alloying with arsenic) and employed it with such success that he founded in Paris a manufactory for platinum ware, which prospered down to 1820. At present the method of compression while hot, without alloying, is used, and that of Jeanetty has been abandoned.

It was only two years after this memoir was written that Deville and Debray perfected the method first proposed by Hare in 1838 of fusing platinum in the flame of the oxygen-hydrogen blowpipe. The memoir is somewhat misleading regarding the process of Jeanty (or Jeanetty), for while it is true that he did for many years manufacture platinum crucibles and other vessels by his method, it was early in the century entirely supplanted by the compression method, and it is doubtful if much practical application was ever made of it.

It is then to Chabaneau that belongs all the honor of having first discovered and employed on a large scale the only method which is in use to-day for preparing a metal, so valuable for chemistry and the arts, and yet no contemporary writer has recorded the claim of our modest compatriot to the glory of this discovery. I apply to him the term modest, for in spite of all our entreaties he could never be persuaded to put forward his just claims. But to-day, as we have before our eyes the letters-patent of the Spanish government, bearing the date of 1783 and testifying to the discovery made by Chabaneau, we come to lay claim for him to the honor of incontestible priority, and to preserve his memory, ungratefully forgotten by his contemporaries.

About 1790 Chabaneau published a large work on the natural sciences in the Spanish language, which was to have been followed by several others, but which was complete as far as regards his specialty. This work, which demanded so much research, night work, and fatigue of every kind, gravely affected his health, and the court physicians prescribed a return to his native air and a period of complete repose. This rest and our climate affected him so favorably that in a few months his health was wholly regained, and he determined to renounce his pension of 15,000 francs in order to dwell in his fatherland and to end in this quiet retreat, in the bosom of his family, a life, hitherto passed among strangers in the midst of the most assiduous labors.

Retiring to the country, near Nontron, he sought to live obscurely, but the jury of the central schools of France besought him to accept the chair of physics and experimental chemistry in the École Centrale of Périgueux. The subjects were so seldom taught at this period that Chabaneau felt it the duty of a good citizen to accept the modest position. His course of lectures, which lasted two years, was printed at the expense of the administration, and published in the year VII by Canler at Périgueux.

On the suppression of the central schools he was offered a chair of chemistry at Paris, and his permission was sought to translate and publish his great work; but, well determined this time to live in his quiet retreat, he refused all these propositions, desiring only to live in solitude and to enjoy the repose so needed and so welcome after all his labors.

He died in January, 1842, at the age of 88, and left no descendant bearing his name. He lived tranquilly, isolated from the world, on his country-place of Clara, near Nontron, dividing his time, like a sage of antiquity, between rural pursuits and philosophical study.

We knew him only in his declining years, but he was then a fine-looking old man, with pleasing and regular features, bearing much resemblance to those of our good and lamented Béranger. His conversation was charming and always instructive. Friend and contemporary of Volney, of Cabanis, of Lavoisier, he was nourished upon their ideas and imbued with their spirit, and they were pleasingly reflected in his conversation.

Thus ends the story which has happily rescued for us from oblivion the life and work of one of the gifted early workers in chemistry. That his name had been forgotten is doubtless chiefly due to his own modesty, but in part also to the fact that his labors were largely carried on in Spain, and his only important published work was in that language. Whatever may be the reason, the atmosphere of Spain has never been conducive to the development of science.

# THE BIOLOGIST'S PROBLEM

By Professor T. D. A. COCKERELL
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THE problem is, to be free without being absurd. Confronted by a series of types, or a series of phenomena, one attempts to classify in an original and accurate manner. In the natural sciences, it is never possible to have the whole of the facts before us. Thus, in paleontology, there is never a complete series of fossiliferous strata; in taxonomy, the materials are always more or less insufficient and must be so. Moreover, were our series of specimens complete, we should still have to reason and speculate about their history and relationships. Still again, if we could assemble and correctly arrange all the data on a given subject, the borderlands of this subject would still remain nebulous, and this no matter how far our researches might extend, unless they compassed all reality, which is impossible.

Artificially, we devise a system which, bounding and restricting facts, gives us the appearance of great precision. We solemnly discuss whether this or that fact falls within this or that artificial category, as if the category were the more real and substantial of the two. We come to know our pigeon holes better than we know the pigeons which inhabit them; and as for those birds which nest in the trees or rocks, we will have nothing to do with them. Thus there arises a species of orthodoxy, quite analogous to that of the churches. A recent writer, referring to the desire of biologists to refer the vital phenomena of certain organisms to mechanical causes, frankly expresses the opinion that "this is a laudable desire." It is laudable to try to make your facts roost in the pigeon holes already provided, rather than elsewhere. In the classification of animals and plants, workers are sometimes divided into two camps, known as the lumpers and the splitters. The lumpers say, let us use large pigeon holes for our data; for all practical purposes, fine divisions are equally useless and unnecessary. The splitters say rather, let us discriminate as finely as we can; but even they have to draw the line somewhere. It is a singular thing that the lumpers actually pride themselves on their lumping; regard it as a virtue to ignore the little facts. The splitters are never quite so self-satisfied, because they are breaking new ground, and are not so sure of themselves. Nearly every naturalist has had a queer feeling when confronted by a long series of apparently new species; a sense of the uncanny, almost a distrust of his own eyesight. Yet in years after, when all these animals have been worked into the system, and each has a little history of its own in the literature, he is apt to find that he was really too timid when he thought himself too bold. He finds, of course, that he made mistakes, but often these are not the ones he feared he might be making.

What advice should be given to one beginning research in some field of biology? If you follow the well beaten path you will not perhaps make many discoveries, but you will not get into trouble. You will at least be biologically respectable. It seems to be the common opinion of university teachers that this is the best plan, if we may judge from the published theses of their students. These studies in cytology and ecology can be worked out much as one works out a problem in mathematics, the data being given, and the result unavoidable unless some gross blunder is made. Taxonomy is often decried by these very men as mechanical, and they avoid it in planning for doctors' theses. The fact is, that it is not mechanical enough; it is too full of ifs and ands, of uncertainties and pitfalls, and as a rule they can not deal successfully with it. On this account we are probably saved from a great deal of bad taxonomy, which would cause infinite trouble to later workers; while the actual output, if not especially brilliant, is at least useful.

From the standpoint of science it seems evident that too much originality should not be encouraged in the young. We need experience in order to deal with difficult matters and break new ground. The older a man gets the more right he has to be free, to depend upon his own judgments even when they run counter to all others. Unfortunately, however, the very experience which seems to justify freedom is the cause of its restriction. Habits are formed, prejudices are developed, the mind is worn into ruts. There are few who can be really original in later life. Thus in the matter of ability, based on knowledge and experience, there is a curve which ascends until the powers begin to fail; but in the matter of originality and freedom the curve soon drops downward, gradually perhaps, but steadily. Obviously, there must be an optimum point somewhere at which it is most possible to make scientific discoveries. It will differ according to the character of the individual and his particular environment; it is for the psychologists to determine for us where it is most likely to occur. Its determination, even approximately, ought to be of some consequence to us.[1] If it is at thirty, then at thirty our brilliant young men and women ought to be most free to do as they will; most free from external difficulties and encumbrances of every sort. Arrangements have not been made to meet

[1] If a hundred persons of good ability would submit annually to a carefully considered series of tests from the years 20 to 40, or as many of these as possible, some pertinent data might be secured. This might be possible in a large city like New York.

this need, but might they not be worth while? The history of science, literature and art alike is full of pathetic instances of men who have been to all intents and purposes enslaved at the golden time of their lives, reaching independence and opportunities for freedom only when it was too late to make much use of them.

If we had the will to make the most of what may be called the *peak of efficiency,* we might at the same time do something to increase its elevation. Nature has doubtless determined its position roughly as corresponding to the time when the growing family needs support and protection. Nature, however, has made no provision for intellectual work which benefits the race at large and in the fullness of time, rather than the individual responsible for it. The very coincidence of circumstances originally favored by natural selection here becomes a stumbling block, and we may only get around it by deliberately planning to do so. That is to say, society must adequately support scientific workers of ability at a sufficiently early age to get the best out of them. No provision for comfortable retirement at sixty-five will be of any particular value in this connection.

Granting the will to make the most of the able originality of our generation, to actively encourage the freedom of those who most deserve it from the standpoint of social utility; can we successfully pick out the right individuals? It is the experience of teachers that originality is a rare product. An eminent teacher of biology told me that he wished to put up in his laboratory the text "many are called, but few are chosen." We are most of us hunting for some genius to grow up under our care and make us famous by reflected light, even as Darwin did Henslow. Why is it that we are, on the whole, so unsuccessful in this quest? Is it that we, old fogies that we are, do not know the thing when we see it? Or is the thing so scarce that we might as well be hunting elephants in Trafalgar Square? Or again, is it that our educational system snuffs out all germs of genius in individuals originally possessing them? Perhaps all these things count in the matter; at the least, the problem is a complex one.

In literature, perhaps more than in science, we often see freedom combined with absurdity. The doctrine that genius and insanity are allied has a certain partial justification in the light of recent work on heredity. It is rare, with our extraordinary tangle of heritable qualities, for any man to have an approximately complete series of characters of the highest grade. Such men, when they occur, become famous, but what we call genius usually depends on one or a few special excellencies. A high quality is like a fine plant, which requires good supporting environment, better than that of common sorts. This should be found, not simply in outside circumstances, but more especially in the other qualities of the man himself. When it is not found there is apt to be a breakdown somewhere. We who are commonplace and undistinguished are not offered a competency for the rest of our lives as the price of a single crooked deal; or if our tastes are cheap and vulgar, they are not enshrined in sculpture or music to go down the ages to our disgrace and the corruption of others. We keep most of our cheapness, our stupidity, our dishonesty, for ourselves and our immediate circle, and much of it is never revealed at all. In the lottery which human inheritance at present is, good qualities will commonly, when they appear, lack the support we could wish for them; but when this is true, there can be no doubt that much of the evil resulting from this can often be remedied by good social conditions. That is to say, we can help the individual to leave unstimulated the bad and to make the most of what is good. Thus, in a sense, he may actually choose his ancestors. Instead of doing this, however, I fear we often do the reverse, and especially is this true when men have to appeal to the multitude rather than to their peers. The eccentricities of modern art and literature, so foreign to the mood of the great masters of the past, may have their root in the want of adequate balance in the make-up of the workers, but they are unquestionably stimulated by a public which, as a newspaper editor once put it, must have the "gewhiz sensation" every morning. Science workers must be sheltered from such demands, and this alone is enough reason for not hastening their public fame until such time as they are too old to learn new tricks.

The much-debated question whether training in one subject increases ability in other quite diverse ones may have some bearing on the peak of efficiency. If it is possible to increase the general ability to deal with problems, without unduly prejudicing the mind in respect to the particular problems to be solved, it seems that the altitude of the peak of efficiency will be increased. The indications are that when one has reached his peak in respect to his particular line of work he may yet find another peak ahead of him by shifting his base to a limited extent. How much, as a rule, it is profitable to shift it might be determined more or less by careful enquiry. I think, however, that from this point of view there is a good deal to be said for taking up a new subject every five or ten years. Even if the altitude of the successive peaks is not increased, it is worth something to have these successive maxima of ability in a life time.

# A COMPARISON OF WHITE AND COLORED CHILDREN MEASURED BY THE BINET SCALE OF INTELLIGENCE

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WHEREVER the methods of science have been inapplicable, or for some reason been left unapplied, opinion has held sway, and, as the adage has it, the number of opinions has equalled that of the men holding them. This, it need hardly be pointed out, is seen clearly in the histories and literatures of religion, philosophy, ethics, politics and many branches of the newer social sciences. It is notoriously true of discussions of race problems, even when the opinions have been held by scientists eminent in their own special domains. Thus we have a Boaz, who can see no essential difference between the negro and white races, and a Le Bon, who is equally certain that a "mental abyss" forever separates the two peoples, and that the negro is the much inferior of the two.

In the hope that the Binet tests would yield a few grains of fact which might leaven the lump of opinion, the writer directed Miss Alice C. Strong, a graduate student of the University of South Carolina, to measure with the Binet scale, as revised by Dr. H. H. Goddard, the white and colored school children of Columbia, S. C. The same tests were given to both the white and colored children under practically uniform conditions, with the exception that some of the colored children tested were older than twelve years. The course of study in the colored school, which is a part of the public school system, is essentially the same as in the white schools, and the quality of teaching is good. The children seemed to be at ease in the presence of the white examiner, and to do their best. No marked variation from the white children in the manner of responding could be noted. In almost every case the dress, cleanliness and manners of the children indicated that they came from good homes. The replies were usually couched in fewer words than those of the white children. There was less tendency to enter into conversation, and it was soon found that they were more at ease when reacting to the tests than when an attempt was made to talk with them about other things.

The following are the tests which were given to the children of both races, ranging from six to twelve years inclusive.

*Six Years:* (1) Is this morning or is it afternoon. (2) What is a fork? a table? a chair? a horse? a mama? (3) Do you see this key? Put it on that chair. Then shut the door. After that bring me the box that is on the chair. Remember, first the key on the chair, then close the door, then bring the box. Do you understand? Well, then go ahead. (4) Show me your right hand. Show me your left ear. (5) Which is the prettier? (Six drawings of heads of women, three pretty and three ugly or even deformed ones, arranged so that the pretty one is now at the left and now at the right are shown the child.)

*Seven Years:* (1) Child must count thirteen pennies placed in a row, touching each piece with the finger as it counts. (2) Pictures representing a man and a boy drawing a cart loaded with furniture; a woman and an old man sitting on a bench in a park in winter; a man in prison looking out of the window, a couch, chair and tables are shown the child, and it is required to describe them. (3) Three unfinished drawings of a woman's head, and one of a woman with the arms missing are shown and the child is asked, What is lacking in that picture? (4) Copy with pen a diamond about three or four centimeters. (5) What is this color? (touching with the finger pieces of red, blue, green and yellow papers).

*Eight Years:* (1) What is the difference between a butterfly and a fly? Wood and glass? Paper and cloth? (2) Count backwards from 20 to 1. (Should be done within 20 seconds.) (3) Name the days of the week. (Must be given in order without omission within 10 seconds.) (4) Arrange in order three 1 and three 2 cent stamps. Child is asked to find by counting how much money it will take to buy them. (5) The figures 4–7–3–9–5 are repeated slowly and distinctly. The child is required to repeat them.

*Nine Years:* (1) Play store, using real money. Child is storekeeper, and is given some pennies, nickels and dimes with which to make change. A four-cent purchase is made, and a quarter presented. Child is required to give change. (2) Child asked to define common objects, same as in 6-year test. Definition must be better than by "use." (3) Name the day of the week, the month, the day of the month and the year. (4) Name the months of the year. (15 seconds allowed.) (5) Arranging in proper order five cubes of same size and appearance but loaded so as to weigh 6, 9, 12, 15, 18 grams.

*Ten Years:* (1) Naming nine pieces of money, *e. g.*, cent, nickel, dime, quarter, half dollar, dollar, two dollars, five dollars, ten dollars. (2) Draw two geometrical designs from memory. (Designs exposed 10 seconds.) (3) Repeat six figures: 854726, 274681, 941738. (4) Questions of comprehension: (*a*) What ought one to do when he is detained so that he will be late for school? (*b*) What ought one to do before taking part in an important affair? (*c*) Why does one excuse a wrong act committed in anger more easily than a wrong act committed without anger? (d) What should one do when asked his opinion of some one whom he knows only a little? (*e*) Why ought one to judge a person more by his acts than by his words? (5) Make a sentence containing the words, Columbia, money, river.

*Eleven Years:* (1) Find the nonsense or absurdity in the following sentences: An unfortunate cyclist had his head broken and is dead from the fall; they have taken him to the hospital and they do not think that he will recover. (*b*) I have three brothers, Paul, Ernest and myself. (*c*) The police found yesterday the body of a young girl cut into eighteen pieces. They believe that she killed herself. (*d*) Yesterday there was an accident on the railroad. But it was not serious: the number of deaths is only 48. (*e*) Some one said "If in a moment of despair I should commit suicide, I should not choose Friday, because Friday is an unlucky day and it would bring me ill luck." (2) Use three words in a sentence (same as in age ten). (3) Say as many words as you can in three minutes. (At least 60 words should be given.) (4) Give as many words as you can think of that rhyme with "day." (5) Make sentences out of these words:

Hour—for—we—early—at—park—an—started—the. To—asked—paper—my—have—teacher—correct—the—I. A—defends—dog—good—his—bravely—master.

*Twelve Years:* (1) Repeat the following seven figures: 2, 9, 4, 6, 3, 7, 5. 1, 6, 9, 5, 8, 4, 7. 9, 2, 8, 5, 1, 6, 4. (2) What is charity, justice, goodness? (3) Repetition of a sentence of 26 syllables. (4) A booklet of six pages contains two horizontal lines on each. On the first three pages the right line is half an inch longer than the left, on the last three the lines are of equal length. The object is to see whether the child will be able to resist the suggestion of the first three pages and see the lines on the last three as equal. (5) A person who was walking in the forest at Fontainebleau suddenly stopped much frightened and hastened to the nearest police and reported that he had seen hanging from the limb of a tree a—what? My neighbor has been having strange visitors. He has received one after the other a physician, a lawyer and a clergyman. What has happened at the house of my neighbor?

The mental age of the child is determined by the highest group of tests he can pass successfully. Only one failure is permitted in each group. If in addition to passing his group successfully the child passes as many as five tests in higher groups he is given an additional year's credit. Thus, if a seven-year-old child pass all or all but one of the seven-year tests and three of the eight and two of the nine-year tests he is rated eight years mentally. Or if he misses two tests in his group, and therefore fails, but passes five tests in higher groups he is rated as normal. If he is more than three years backward he is mentally defective. The tests begin with the group corresponding to the child's physical age, *e. g.*, a child eight years old is tested first with the eight year old tests, and then with the seven or nine, as the case may require.

The results of the investigation upon the white and colored children may be briefly summarized as follows:

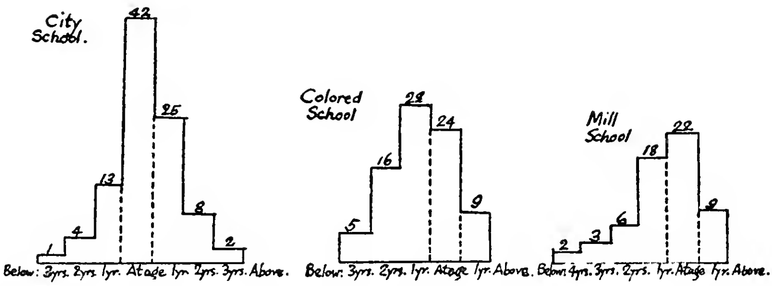
| | Colored, Per Cent. | White, Per Cent. |
|---|---|---|
| More than one year backward | 29.4 | 10.2 |
| Satisfactory | 69.8 | 84.4 |
| More than one year advanced | 0.8 | 5.3 |

The number of white children testing at age is decidedly larger than any other group, whereas for the colored children the largest group is the one testing one year below age. In the satisfactory group there is a difference of nearly 15 per cent. between the white and colored; nearly three times as many colored are more than a year backward, and less than 1 per cent. are more than a year advanced.

The picture tests gave the colored children considerable trouble, probably due to difference in racial esthetics. The tests relating to time and money, distinguishing between morning and afternoon, enumerating the months, counting stamps and making change, the drawing tests, both copying and reproducing from memory were all too difficult. The answers to the questions of comprehension, to the absurd statements and to the problems of various facts, were often absurd or senseless; the best replies, however, compare very favorably with those of the white children. The definitions were often not better than terms of use, and frequently stated in the language of a younger child.

In general it may be said that the colored children excel in rote memory, *e. g.*, in counting, repeating digits (but not one was able to repeat 26 syllables), naming words, making rhymes and in time orientation. They are inferior to the whites, however, in esthetic judgment, observation, reasoning, motor control, logical memory, use of words, resistance to suggestion and in orientation or adjustment to the institutions and complexities of civilized society.

To what extent these differences are due to difference in racial intellectual ability, and how much to environmental influences, differences in physiological age, or other subtle factors, can not be dogmatically stated. They are certainly not due to difference in school training. In order, therefore, to make the comparisons as just as possible, and at the same time ascertain the extent of the influence of environment, the white children were divided into two groups—city children and mill




children. The economic, educational and environmental conditions of the cotton-mill children are but little, if any, better than those of the colored children. The results of the comparison showed that the proportion of colored children who are satisfactory is less than that of the mill children, which in turn is less than that of the city children. Less than 6 per cent. of the city children are more than a year backward, 18 per cent. of the mill children, and 26 per cent. of the colored children. None of either the mill or colored children test more than one year above age, while 10 per cent. of the city children do.

These facts and the figures upon which they are based appear more vividly in the following graphs:

Another table of statistics showed that the colored children made a better showing in the first five grades than in the first seven, but their inferiority to the whites existed throughout the school years, contrary to the widespread opinion that colored children are as well, if not better, endowed during the first school years. Again, according to the Binet scale, a larger number of white children are in a school grade below their mental ability than above, whereas the reverse is true of the colored children. A rough classification into three groups, according to color—dark, medium, light—showed that the darkest children are more nearly normal, the lightest show the greatest variation, both above and below normal.

The limitations of the study are evident. It is but a crude beginning of a subject that will doubtless soon be opened up and made to yield interesting and profitable data. It need not be pointed out what radical changes would have to take place in our educational theory and practise, as well as in our social philosophy, if it should be shown conclusively that races differ in mental capacity and aptitude just as they do in physical appearance. No final conclusions, however, are here offered, nor is any attempt made to settle once and for all the question of race superiority or inferiority. That requires investigation along many lines hardly opened up as yet. But this much we may surely conclude from the above study: that negro children from six to twelve and possibly fifteen years are mentally different, and also younger than southern white children of corresponding ages, and that this condition is partly due, at least, to causes that are native or racial. That is, if MM. Binet and Simon had originally tested southern negro children they would have worked out from the results a scale which would have been different from their present one in several respects, and which when applied to southern white children would be found to be, for the most part, a year or more too young, though possibly there would be some tests which would yield the opposite results.

Perhaps some day each branch of the human family will have a Binet scale of its own. Then, by a wholesale interchange of tests, as we do now with professors, it will be possible to determine wherein a given people are proficient and wherein deficient; and later, perhaps, by adding coefficients and credits to settle mooted questions of racial rank. But this again belongs to the realm of speculation.

Probably the point of greatest value brought out by this study is that perchance a key has been found in the Binet scale which will prove of the greatest service in the solution of problems in contemporary folk-psychology and race and social adjustments. Certain it is that these important human problems need the spirit, methods and instruments of science applied to them. The Binet scale is the first instrument that has appeared.

# THE STRUGGLE FOR EQUALITY IN THE UNITED STATES
## II

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### The Railways and Fair Play

SINCE the close of the civil war, the American people have devoted their energies largely to the development of their material resources. In 1865, the men who had served in the armies of the south as well as of the north returned to the pursuits of peace and, reinforced by the rising tide of immigration, the nation entered afresh upon the industrial conquest of its environment. Aided by the homestead act, the railway and improved farm machinery, and more recently by irrigation works and the scientific expert, the agricultural development of the country has gone forward by leaps and bounds. But material development has not been one-sided. The growth of manufactures, the increase of commerce and railway expansion, have been even more conspicuous than the development of agriculture. More noteworthy still, probably, are the changes which have taken place in the mode of businesss organization. The corporation has displaced the partnership, and the size of the business unit necessary to a maximum of efficiency has enormously increased in many fields of activity. A process of consolidation, combination and integration has gone on that has transformed the business world. The change marks nothing less than a revolution. As a consequence, the individual and small combinations of individuals find themselves in the presence of adamantine forces with which they are powerless to cope, and the conflict between equality and property has shifted to a new field. The energy and ambition of the age are so centered upon economic ends that equality of industrial opportunity is the crying need of the hour.

### I

Among the new forms of property that have violated the sense of fair play, that embarked in the several fields of transportation and communication is easily chief. This is preeminently true of the railway. In a highly specialized industrial system, where nearly everything is produced for sale, the mass of commodities at some stage in its career enters the channels of transportation. Under these circumstances, equality of opportunity in the matter of reaching the market concerns the consumer as well as the producer and is fundamental to industrial liberty. There was a time when the paramount problem in most communities was how to get a railway. After the railway came, the problem of how to make it subservient to the welfare of the community was scarcely less pressing. For it soon appeared that the railway by the adjustment of rates could decree where commodities should be produced, build up or tear down a community, and make or mar the fortunes of individuals. Besides, railway managers exercised an undue influence over the press, the actions of legislatures, executive officers and even the courts. Among the various kinds of railway favoritism, none was so invidious as the railway pass, and certainly none exerted a more subtle and corrupting influence. It gradually dawned upon the public mind that here was an industry which competition, upon which people had been accustomed to rely, was ineffective to control. Competition made for instability as well as for unjust discriminations in rates, promoted the needless construction of roads, and was therefore often ruinous alike to the investor and the shipper, and sometimes it permitted monopoly by refusing to work at all. To permit railway managers to make every rate a matter of special bargain and sale according to the supposed necessities of competition was intolerable. To leave the problem at the pleasure of the railway interests to solve by pools, rate agreements and other forms of combination, including consolidation, was to sacrifice the public interest to the greed of the few. Apparently, nothing less than the coercive power of the state was equal to the situation.

## II

Probably the farmers of certain western states were the first to feel the full power of railway oppression. Long distance from market made them in a peculiar way dependent upon the railway. Since they were for the most part pioneers, they were ill prepared to stand the pecuniary losses to which they were subjected, and were quick to resent what seemed to them a manifest injustice. Besides, the fact that few of the railway bond and stockholders resided in the west made them appear as aliens, and contributed to the zeal with which the "embattled farmers" attacked the railway problem. These conditions blossomed into the granger movement which gained control of the legislatures of a number of states, and either directly by legislative enactment or indirectly through railway commissions endeavored to curb the railway power. The problem presented was almost wholly new, and the members of the different legislative bodies were without experience in meeting it. Naturally, not a little crude and ill-advised legislation resulted, but the issue between the rights of property, on the one hand, and fair play, on the other, was nevertheless fairly and squarely joined.

The railway interests did not submit to public control without a bitter contest. In defense, the attorneys of the railways banked much upon the doctrine of charter rights announced in the Dartmouth College case, and placed great store upon the constitutional guaranties of private property to which certain decisions by state courts seemed to lend color. In 1869, the Supreme Court of Iowa decided that a railway is essentially private property and in no sense public, and in the following year the Supreme Courts of Wisconsin and Michigan handed down similar decisions.[1] In 1871, Judge Brewer, then a member of the Supreme Court of Kansas, in a dissenting opinion said:

> A railroad is founded upon an absolute property-interest. The corporation owns everything. The interests it possesses have all the attributes of absolute property.[2]

These opinions appear in cases where the right of railway companies to enforce the levying or payment of taxes voted to subsidize construction was questioned on the ground that a tax for a private purpose is invalid.

In the face of these opinions, the contention of the railway attorneys was overruled and the regulative power of the state was upheld in Munn *v.* Illinois, Ruggles *v.* Illinois and other cases. It was held that property embarked in a railway is clothed with a public purpose and therefore properly falls within the police power of the state. The fact that a railway corporation is the creature of the state, in the opinion of the Supreme Court, constituted an additional ground for state control of rates. In regard to the Dartmouth College case, the rule of strict interpretation of all charter rights was adopted. It was maintained that the right of the state to regulate railway rates can only be bargained away by language that admits of no uncertainty, that any and all doubts about the meaning of charters are to be construed in favor of the state, and that the power of the state to regulate does not lapse by non-user. In the early "granger decisions," the Supreme Court even went so far as to say that the final authority in the fixing of rates rested with the legislature and not with the courts, and that if the former reduced rates unduly the remedy of the railway interests was political rather than judicial. But in Chicago, Milwaukee and St. Paul Railway Co. *v.* Minnesota in 1890, it was held that a rate fixed by a state railway commission is subject to judicial review. Under this and subsequent decisions, the reasonableness of practically every rate fixed by a state legislature, either directly or through a commission, can be called in question in the federal courts, and the police power vested in the state legislatures is subjected to an important restriction.

[1] Iowa Supreme Court Reports, 27, p. 28. Wisconsin Supreme Court Reports, 25, p. 167. Michigan Supreme Court Reports, 20, p. 452. These references are taken from an unpublished manuscript upon ''Farmers' Organizations, the Supreme Court and the Railroads,'' by my father, Simon Emerick.

[2] Kansas Supreme Court Reports, 7, p. 542

## III

The movement to regulate railways engaged in interstate commerce has run a similar course. The Interstate Commerce Act passed by Congress in 1887 was the logical sequence of the Supreme Court in the year immediately preceding, in Wabash, St. Louis and Pacific Railway Company *v.* Illinois, deciding that the states have no right to regulate interstate commerce. Subsequent court decisions, however, so interpreted the act of 1887 as to leave the Interstate Commerce Commission without the substance of power. But successive amendments have in large measure made good its deficiencies and enlarged the scope of its authority. In 1896, the power to compel witnesses to testify was definitely obtained. The Elkins law of 1903 subjected the railway corporations which violate the law as well as their agents to a fine, and made the recipient as well as the giver of a rebate guilty of a misdemeanor. Any departure from the published rate was prohibited. In 1906, the power to fix a maximum rate was expressly granted the commission in addition to the power to declare a rate unreasonable which it already possessed. To prevent "midnight tariffs" thirty days' notice of change in rates was required. In 1910, the commission was empowered to suspend all advances in rates, and an attempt was made to clothe it with greater power in administering the long and short haul clause. The authority to establish and enforce reasonable classifications of property for transportation was also bestowed. Express and sleeping car companies, pipe lines used in transporting oil, and telegraph, telephone and cable companies have been included within the sweep of the law. Once more, plenary power over the accounts of the railways has been granted. Manifestly, if publicity and uniformity of accounts are as important to the solution of the railway problem as many suppose, the most decisive step has been taken.

Moreover, since 1906, it is no longer practicable for the carriers to disobey the orders of the commission with impunity as was previously the case. For cumulative penalties begin to run the moment an order becomes effective unless the carrier secures the intervention of a court. As a consequence, the commission has a certain standing and dignity which it has not hitherto enjoyed. It is probable also that interference by the courts will be less common in the future than in the past. The present law restricts interference to cases where the act complained of is either ultra vires or unconstitutional, and the Supreme Court decisions overruling the pretensions of the Commerce Court indicate that an established place has been won for the commission. Such are some of the more important facts incidental to a movement which has been subjecting railway property to public control in the interest of fair play.[3]

[3] Frank Haigh Dixon, "The Interstate Commerce Act as Amended in 1906," *Quarterly Journal of Economics,* Vol. 21, 1906, pp. 22–51, and the "Mann

## IV

There is no doubt of the competency of the State to prescribe the weight of a loaf of bread, as it may declare what weight shall constitute a pound or a ton. But I deny the power of any Legislature under our government to fix the price which one shall receive for his property of any kind. If the power can be exercised as to one article, it may as to all articles, and the prices of everything, from a calico gown to a city mansion, may be the subject of legislative direction.[4]

So wrote Justice Field in a dissenting opinion in Munn *v.* Illinois. In the light of the general trend of court decisions as well as of legislation, it is apparent that this view is altogether too sweeping. If the highest court in the land has occasionally set at naught the railway legislation of congress and of the states, it has also brought the railways within the condemnation of the anti-trust act in the Trans-Missouri Freight, Joint Traffic and Northern Securities cases. Moreover, adverse court decisions have in large measure been overcome by additional legislation. Probably not a single member of the Supreme Bench to-day regards the view expressed by Justice Field as good law.

There has been a marked tendency during the last decade to clothe the railway commissions of the several states with more drastic powers. Some states have even gone so far as to fix rates by legislative enactment in addition to creating a commission with mandatory power.

No less than fifteen new or remodeled commissions were created in the two years 1905–1907, bringing the total number by 1908 to thirty-nine. Practically all of these were of the so-called "strong" type; that is to say, possessing the most extensive powers over all matters of rate operation and in many cases of finance as well. The most notable of these, of course, were the so-called Public Utility Commissions of Wisconsin (1905) and New York (1907). The subjugation of the formerly dominant railway interests in New Jersey and Pennsylvania was also highly significant. The movement has even invaded the New England States—so long a sanctuary of the "weak" or advisory commission. Vermont and New Hampshire set up powerful boards, . . .[5]

The consolidation of railways, the rise of freight rates in the years following 1900, "the inordinate concentration of financial power in the hands of a few privileged individuals," and the power of the newly created industrial combinations to secure concessions in rates contributed to this result.[6] The same conditions have made for more stringent federal control of the railways. Even Massachusetts has given up her advisory commission. For years this staid old commonwealth stood out for a "weak" commission. It was confidently claimed that such a commission had all the advantages of one of the strong type minus the disadvantages. On the one hand, if backed by public opinion,

Elkins Act, Amending the Act to Regulate Commerce," *ibid.*, Vol. 24, 1910, pp. 593–633.

4 United States Supreme Court Reports, Vol. 94, 1876, p. 93.

5 William Z. Ripley, "Railroads, Rates and Regulation," p. 629.

6 *Ibid.*, pp. 487–492.

its recommendations had practically the same effect as a statute, for there was ever the possibility of the legislature enacting them into a law. On the other hand, if its recommendations went beyond those for which the public was willing to stand, the mistake of carrying state regulation too far was avoided. The progress of railway monopoly, however, finally carried the day for a commission with mandatory power over rates and other matters.

The chief point of attack upon the railways has been discriminations. The general average of railway rates has been so low that there has been comparatively little complaint on that score. There is, however, a pronounced tendency to subject the general average of rates to state control as railway consolidation more and more approximates a condition of monopoly. But the burden of protest has been that some rates are out of proportion to others, and the facts narrated above are but milestones in the efforts of a people to realize conditions that square more nearly with the sense of justice. Some of the legislation that has been passed has been enacted with undue haste and in a spirit of resentment, and in attempting to get rid of discriminations and at the same time preserve competition some of it has been contradictory. But to hold that it is at bottom the work of self-seeking demagogues and hair-brained agitators is to overlook the very real grievances that have existed and to underestimate the general good sense and intelligence of the people. The main trend of railway legislation in the United States is so much in accord with that in other countries as to warrant the presumption that it is moving in the right direction. As compared with those countries in which the railways are owned and operated by the state, American railway policy is moderation itself. The demand for public regulation is not a popular caprice of the moment. Its persistence and increase in the face of hostile court decisions and in spite of blundering mistakes forbid this view. In the future as in the past, "fool legislation" may result in a temporary reaction. But few railway managers look for a relaxation of governmental control, and many of them will be surprised if they do not get more. The recent Supreme Court decision in the Minnesota rate case not only upheld the authority of the state in the main, but it suggested that federal control of interstate commerce has not yet been pushed to its constitutional limits. The end is not yet in sight.

When the farmers of certain western states in the early seventies arose against the railways, there was a general disposition to treat them with contempt. Were they not a lot of ignorant frontiersmen? What chance had they against the railways? What did they know about railway management? Was not the railway in common with other industries amenable to competition? Those in the higher walks of life, with rare exceptions, deprecated the attitude of the farmers. Their position was grossly exaggerated and misrepresented. The rantings of their more extreme spokesmen were cited as proof that they were wholly without any just ground for complaint. Many thought them bent on confiscation. The hard times following the panic of 1873 were laid at the door of the granger legislation. Nevertheless, the main contentions of the farmers were upheld by the Supreme Court. The granger movement did much toward changing the railway policy of a nation.[6a]

Professor Ripley well says:

> Great laws are not the figments of men's minds, conjured up in a day. They are a response to the needs of the time. Their true causes are thus immeasurably complex. Nor does a wholesale public demand for legislation arise overnight. From small beginnings the pressure steadily grows, oftentimes for years; until, perhaps through a conjuncture of particularly aggravating events, matters are at last brought suddenly to a head. Yet while this culmination of industrial or social pressure may finally result in legislation under some particularly strong political leadership, to assign such personal influences as even the remote cause of legislation, is to belie all the facts and experience of history. No clearer illustration of the close relationship between economic causes and statutory results could perhaps be found, than in the field of our federal legislation concerning common carriers. It forms one of the most important chapters in our industrial history.[7]

## Fair Play in Other Directions

### I

The demand for equality of opportunity at the hands of the railways is part of a much larger movement. The widespread protest against the undue exactions of public utility enterprises in various cities, and the creation of commissions for their control is but another phase of the same thing. Likewise, the movement for the control of the large industrial combination is at bottom a demand for fair play. The revolt against the business methods exemplified by the Standard Oil and the American Tobacco Companies made these concerns so notorious that the Supreme Court ordered their dissolution. In the course of these decisions, price-cutting limited to a portion of the market or to a single line of goods produced by a trust, trade wars which aim at buying up com-

[6a] Solus Justus Buck, "The Granger Movement," Chapters IV., V. and VI.

[7] William Z. Ripley, *op. cit.*, pp. 441–442. Hadley's "Railroad Transportation" and Johnson's "American Railway Transportation" contain good accounts of the movement for state and federal control of railways in the United States. These two works also contain accounts of the relations of the state to the railways in the principal countries of Europe. Ripley's "Railroads: Rates and Regulation" gives a sympathetic and detailed account of the movement for the control of railway rates by the federal government, but treats only incidentally of the activities of the several states. "Railway Problems," by the same author, contains an excellent selection of reprints. Merritt's "Federal Regulation of Railway Rates" contains a digest of the more important cases that have been decided by the Inter-state Commerce Commission.

peting plants and at closing them down, refusal to sell or to allow the customary discounts to purchasers who buy any of their supplies from a competing establishment—these and like methods which aim at excluding others from any industry by playing upon their fears were either expressly or by inference condemned. Trade agreements which bind large numbers of capable men for long periods not to compete in a specified field were also held anti-social. These methods were judged unfair not by any new code of ethics but in the light of the time-honored principles of the common law.

The extremity of the remedy sanctioned by the Circuit Court to which the American Tobacco Company was remanded for dissolution is noteworthy. Not only was the company disintegrated into four new companies, but each of the four was forbidden to control more than forty per cent. of its branch of the business, or within a period of five years to acquire any stock in one of the others. Twenty-nine individual defendants were enjoined for three years from increasing their holdings of stock in the new companies. For a term of five years, moreover, no two of the new companies shall have the same person serving as an officer or director, or employ the same agency for the purchase or sale of tobacco or other material.[8] It is more than doubtful whether these and similar remedies approved by the court will prove adequate to restore competition. But be this as it may, we have here limitations upon ownership in the interest of the public weal that would hardly have been thought possible a generation ago. There is the possibility therefore of still more drastic restrictions in the future if those already resorted to fall short of their purpose. It is noteworthy, also, that the Chief Justice in writing the Standard Oil and the Tobacco decisions did not question the power of Congress, under the commerce clause of the constitution, to limit the quantity of property which an individual may acquire and own, or the power to interfere with the right to acquire and own stock granted a corporation by a state, though he emphasized both of these points at length in his dissenting opinion in the Northern Securities case, Chief Justice Fuller, Justice Peekham and Justice Holmes concurring.[9] Neither did the case of the United States *v.* E. C. Knight Co. upon which the defendants banked much stand them in good stead.[10] The open-mindedness of the court augurs well for the future.

## II

The spirit of fair play is expressing itself in sundry other directions. The movements against child labor and for compulsory education are cases in point. These movements aim at starting the members of the

[8] *The New York Sun*, November 9, 1911, pp. 1–2.

[9] William Z. Ripley, "Trusts, Pools and Corporations," p. 379.

[10] United States Supreme Court Reports, Vol. 52, L. ed., October, 1910, p. 648.

next generation on more equal terms in life. The tendency is to emphasize parental obligation rather than the claims parents have upon their children. As the opportunity to acquire a free hold on the public lands has diminished, the necessity of creating other opportunities by education has come to be more generally recognized. Hence the growing liberality with which the public school systems and the state universities are supported by taxation. Trade and continuation schools are helping to bring the individual into better adjustment with his environment. The splendid system of high schools in New York City is the work of the last fifteen years. The metropolis has also undertaken to provide adults with education upon all sorts of subjects by means of lectures. Not only have the obligations of parenthood increased, but man's masterful position in the home has declined. The common law has been modified until the property rights of the married woman in many states are essentially on a par with those of the married man, or at least the trend of affairs is clearly in this direction. The idea that woman is man's inferior is in growing disrepute, and one avenue of usefulness after another is being opened to her. The movement for "votes for women" is progressing rapidly throughout the civilized world. Likewise, the health of the common man has ceased to be a matter of indifference and has become a matter of public concern. The fact that no portion of society is safe so long as any portion is left to fester and rot is more fully understood and acted upon than ever before. The fall in the death rate indicates an improvement in the state of the masses of mankind. Such scourges as yellow fever and cholera have apparently been banished, and well-defined limits set to the ravages of smallpox, diphtheria, scarlet fever and many other diseases. Again, the enactment of more stringent corrupt practises acts aims at abridging the influence which the property-owning classes exert in public affairs.

## III

The insistent demand for direct primaries, the initiative, the referendum and the recall indicate a disposition on the part of the rank and file to have more to say in our political and civic life. The object of these institutions is to make our representatives more truly responsible to those whom they are supposed to represent. They evidence the popular distrust in which our legislative bodies are held. They are the result and not the cause of the failures of representative government. They are the weapons with which the people are seeking to defend themselves against the aggressions of office-seekers and the property-holding class. The one-time boss of Cincinnati, George B. Cox, was recently quoted as saying:

> I made good in politics because I never lied to any one and because I never went back on a friend. What is more, despite some criticism to the contrary, I always tried to serve the people.

What is here recognized as an afterthought, it is hoped direct primaries, the initiative, the referendum and the recall will compel every politician to keep uppermost in mind. It is clear that the efficiency of these institutions depends upon the intelligence and good sense of the people. Unless used with discretion, they will prove to be as useless as a rusty knife. Conspicuous instances of their utility, however, are not lacking. But for the referendum the Cincinnati Southern Railway would have been sold away from the city for a tithe of what it was worth, just as the streets of the city were handed over for fifty years as a gift to a street railway monopoly. Lecky tells us:

> In England, a large class of politicians are now preaching a multiplication of small democratic local legislatures as the true efflorescence and perfection of democracy. In America, no fact is more clearly established than that such legislatures almost invariably fall into the hands of caucuses, wire-pullers, and professional politicians, and become centèrs of jobbing and corruption. One of the main tasks of the best American politicians has, of late years, been to withdraw gradually the greater part of legislation from the influence of these bodies, and to entrust it to conventions specially elected for a special purpose, and empowered to pass particular laws, subject to direct ratification by a popular vote.[11]

Among other things expressive of the spirit of the times is the reduction of tariff duties, the movement for currency reform, the reform of the general property tax, the income tax and socialism. The first aims at taking the determination of tariff schedules out of the hands of special interests, or, at least, at imposing some restraint upon them other than their own moderation. There is no more reason why the beneficiaries of the tariff should be given a free hand in fixing tariff rates than there is why one business man should permit another with whom he deals to fix the price without let or hindrance. The second aims at preventing the general distress which the collapse of our banking system now and then occasions. It also seeks to prevent the concentrated control of banking in the hands of the few and to place the facilities of credit at the disposal of every one entitled to them. The third and fourth seek to distribute the burden of state and federal taxes in a more equitable manner and to tap additional sources of revenue. The general property tax in many states involves gross inequality in the assessment of realty and the total escape of the bulk of personalty from taxation. Much is to be said in favor of the income tax in comparison with the tariff on sugar. The sugar industry does not promise to become self-supporting. As a young industry, therefore, it is hardly worthy of further protection. The whole of the income tax will go to the government, whereas part of the enhanced price of sugar has gone into the pockets of the sugar producers. Moreover, sugar is an article of general consumption and an import duty upon it is practically a capitation tax. On the other hand, an income tax is based roughly upon ability to pay. If col-

[11] "Democracy and Liberty," Vol. 1, p. 282.

lected at the source, it can not be evaded. The tax on sugar has excited little protest because it has been paid unconsciously. It has been concealed in the price. "Few people taste the tax on sugar in their tea." There is little likelihood of such a tax being shifted upon the well-to-do. It is practically certain, however, that the incidence of the income tax will fall in part upon this class. "Historically considered, income taxes have been more or less successful efforts to throw an increased share of public expenses upon the wealthy."[11a] The fifth, socialism, sums up the drift of the age towards property better than any other word. It expresses the humanitarianism of the time. Tenement house owners and steamship companies are confronted with regulations that are growing more stringent. Private property in the wasting resources of nature is being abridged in the interest of posterity. The liability of employers to employees for accidents is increasing. Assumption of risk, contributory negligence, and the fellow servant doctrine are fast being abrogated by statute. A system of social insurance is being instituted that is distributing the unmerited hardships due to accidents, sickness, old age and unemployment in a more equitable manner. There is no more indubitable sign of progress toward the ideal of equality. Factory legislation is spreading and is becoming more exacting. The hours of labor are more and more being regulated in the interest of the public health and safety. The fixing of minimum rates of wages is seriously discussed. Social legislation is looked upon as promotive rather than as subversive of liberty and a new conception of liberty is gaining ground.

Fundamentally, socialism is not a disease but a symptom and a remedy for a disordered social condition. For this reason it demands serious attention and can not be laughed out of court. No political party is immune from its influence, but the rapid increase in the vote of the Socialist party, the growing volume of discontent, and the large vote polled by the newly organized Progressive party in 1912 indicate that neither of our two historic parties has been keeping step properly with the times. Many people vainly imagine that socialism can be disposed of by pointing out the absurdity of certain of the dogmas of Marx, such as the class struggle and surplus value, to which some doctrinaires subscribe. Nothing can well be farther from the mark. The only effective way to meet socialism is to correct the economic and social conditions which account for its origin and existence.

> Men do not become discontented because they have theories, but have theories, because they are discontented.[12]

[11a] Winthrop More Daniels, "The Elements of Public Finance," p. 187.

[12] Walter E. Weyl, *op. cit.*, p. 189.

(*To be continued.*)

# THE DEMOCRATIC ORGANIZATION OF A STATE UNIVERSITY

By Professor JOSEPH K. HART
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DEMOCRACY has been working for more than a century to understand its own genesis and genius; but not enough attention has been paid to the most central element in the development of the complete democracy of the future. We have talked too much about ideals, but not enough about methods of realizing our ideals. Fallacious methods prevent the attainment of the things we most desire.

It is felt by many, perhaps by most, that self-government demands particularly strenuous processes of education in the development of the young. This is an ideal: but it has not been felt by many that a democratic social order must see to it that the public education institutions shall be thoroughly democratic in all their parts—in methods, in processes, in atmosphere, in actual results, as well as in ideals; and that this democratizing of our educational institutions is the most fundamental problem of democracy.

One type of American teacher has distinctly taken the attitude that the public schools must be absolute monarchies, with the head teacher as monarch and all other members of the school as his subjects, vassals and slaves, in order that these ideals might be compelled in all of them. A great American teacher has said that the school is the modern representative of the old Roman Empire with its arbitrary demands that the barbarians shall yield to the civilizing influences of education.

But, as stated above, it would seem that if education in a democracy is to be for democracy it must be democratic in every respect. The school, claiming to be the intellectual institution of the community, should be able to recognize the logic of such a statement and accept it.

This should certainly be true in the case of the university of a state, at least. Usually a university claims to be the center of intelligence of the state. But, if it is to be recognized as the center of intelligence in the democracy, it should be willing to take the most intelligently democratic point of view that is attainable.

Under a completely democratic conception of education what will be the nature of the organization of a state university? Such an institution attempts to bring together two rather inharmonious ideals or points of view, and usually one or the other of these ideals secures an undue advantage, thereby limiting the work that should be accomplished by the whole institution. The primary ideal of a state university should be *service to the state.* As a great modern teacher has said, our "State universities should be training schools for servants of the common weal." But as *institutions* universities tend to take upon themselves conventional ways and to become ends in themselves; or to set up ends of their own, which are to some degree unrelated to the purposes which underlie their original foundation in the civic life. Even a state university may come to feel that it has its own sufficient standards and its own complete internal tests as to what should be considered the constituents of its own success.

The university ideal has always been an aristocratic rather than a democratic ideal, and it is with difficulty that the state university accommodates itself completely to the democratic ideal of service to the whole state. That old aristocratic ideal has held that culture is a possession of the exceptional individual and an adornment of living, rather than a great social goal and the preparation of all individuals for real service in the common good.

How can these two ideals—the one of public service, the other of personal culture—be harmonized in a state university? The real problem that faces any such an institution at any time is this: how can we keep the university ideal of a great institution of learning, and at the same time keep the state's ideal of service to the welfare of the whole people? It is easy to become purely formal, on the one hand, and to insist that learning is its own excuse for being; that the idea of use degrades culture; and that the state can well afford to support an institution devoted to the purposes of learning, whether that learning have any actual relationship to the life and problems of the state or not. On the other hand, it is almost as easy to take a purely utilitarian view of such an institution and to assert that any sort of activity that can call itself service to the people is worth doing, and that any sort of development of learning in the abstract is a waste of the state's resources.

Neither of these two tendencies must be permitted to become dominant. Each is an extreme from which the institution must be saved. Formal culture is not a democratic ideal; neither is a purely utilitarian "service to the state" taken by itself. The former becomes aristocratic and unsocial; the latter becomes inane, futile, useless. How can the state university maintain both these ideals, the one, of learning, the other, of service, at the same time? How can it make sure that these two ideals shall mutually nourish, criticize and develop each other?

In the first place there should be a board of control, made up of representatives of the people, who have a real interest in the development of such a completely democratic institution. This board should be inclusive of the whole social life of the state—industrial, professional, commercial, cultural—and in addition they should have some comprehension of the *inner meanings of education.* That is to say, they should be men and women who realize that the world moves on, and that education is central in that movement.

They should have, for their services as representatives of the people in the control of the state's highest institutions of learning, a broadly social conception of education, and an understanding of the power of truth, a real love of truth, and a belief in the growth of truth in the life of the individual and the state.

There should be also on this board of control at least one member, man or woman, who understands something about the scientific nature of educational methods and processes, so that the board will be able to determine, by *its own intelligence,* whether the work of the university is being well done or not.

The members should be able to form for themselves a great working conception of the purposes of a state university and a general working program for such an institution. Such a conception will rightly gather around some such ideal as the following: A state university is a group of men and women of all degrees of general development, from the boys and girls just in from high school, to the mature men and women who may be leaders of the thought and action of the state. Whether young or old, these members of the university should all be students—seekers after truth, sincerely interested in life and its problems. But first of all they should be real men and women, real citizens of the state, and real members of society.

At the lower fringe of the group they may be primarily learners, at the upper fringe primarily teachers; but, both above and below, and especially in the great central main mass of the group there should be a natural and healthy mingling of the two attitudes. That is, they should be students, who are learning and teaching, and teachers who are instructing and learning.

So, all in all, a state university should be a group of men and women who are trained, and are in training, for service in the actual life and problems of the state; who are becoming intelligent in their work, and who are preparing to help the state solve its present and future problems, as true *state's men* and *state's women,* servants of the commonwealth and leaders in the constructive, democratic life of the state. And if they are not of this type, then there is no real reason why they should be members of the university, as teachers; and if they can not reach this point of view, there is no real reason why they should remain as students.

There should be, as president of the university, a man of broadly democratic and social intelligence, interested in all aspects of education and capable of understanding the meaning of democratic service for the state. The executive attitude and interests should be profoundly public, civic, social. In no sense should the executive feel a personal ownership in the university; but he should have a sense of personal responsibility, that the university must be administered in such ways that the present democratic aspirations of the state for a larger life may be met and the future democratic life of the commonwealth may be provided.

For these reasons one of the executive's chief characteristics should be his ability to appreciate men and his willingness to judge of the worth of men for membership in the university, either as teachers or as students, by the promise that they show of ability to contribute something constructive to the progress of democracy. At the present time, in many schools, the efficiency of strong men is lessened by the petty tyrannies of executive control and by undemocratic forms of domineering authority which serve no purpose save the satisfaction of the petty tyrant involved. The president should see to it that the strong men and women of the university faculty are given broad freedom to work, both within and without the university, at those constructive programs which they are prepared to offer. The president's real service to the university and the state is not in his own exaltation; but only in his securing to the university a field for broadly social educational work, and in his securing teachers of the right sort to occupy this field. There are men in every university who have these broadest ideals of social scholarship, "learning at work in the service of the state," who need to have larger freedom for their work.

Such a president will, however, scarcely ever be chosen by a board of control acting independently. As a matter of fact a democratic organization of the university would demand that the people of the state, represented by the board of control, the faculty, represented by a committee elected by themselves, and the student body, represented by a committee chosen in the same way, should all have a share in the selection of the president. He is to be the representative of the people. He is to work with the faculty. He is to be a leader and an inspirer of the student body. How can he be all of these unless all of these interests have some share in his choice? The state might well pay any sum needed to secure such a man.

If we turn for a moment to a more definite discussion of the faculty, it should be said that a faculty for such an institution should be made up, mostly, of real teachers; that is, of men and women who are interested in teaching young men and women rather than in research work, and who have just enough of the research ideal to give them zest for their work and to keep them, intellectually, active and young.

There should be, undoubtedly, in each department a real research man, whose main function should be to stimulate the constant growth of the department along intellectual lines. But the faculty as a whole should be interested primarily in the social outcome of education rather than in the purely intellectual outcome. They should be trained teachers with the social point of view; that is, with a conception of truth as something that comes up out of the great social world and returns into the greater social world to make life more complete and worth while.

There should be no teaching of the younger members of the university by mere research men. The first contact of the freshman with the university should be with the broadest and sanest members of the faculty. That is to say, the faculty should be strong enough to be able to afford real teachers for the freshmen. There is more to be said with reference to the organization of the faculty and the university in general, but before proceeding to that a brief statement is necessary here about the student body.

The student body is, of course, the most important part of the university. The rest of the university exists for the sake of the student body. A university student body is always, under normal conditions, an inspiring body.

In turn, they should be constantly inspired. They should be so carefully looked over on their entrance to the university that the state may be perfectly assured that none is among them merely to waste time and squander the resources of the state and his own life.

And thus assured of their interests and their ability, the students should have some real share, some genuine control in the organization and life of the university. The university exists to minister to the growing life of the students. It should be used by them as a means to their education; and since education is a broadly social process, the university must recognize its broadly social meanings and organize itself, democratically, along all the lines that minister to, that support, that compel or nourish any element of democratic personality. The spirit of genuine cooperation and effectiveness should be apparent everywhere; and old-time aristocratic suspicions of the student body should be done away with. Real training for democratic living can come only through sharing real responsibility.

Let us now return to a more complete discussion of the organization of the university. The whole faculty, every member being present or accounted for, should come together daily for at least a week before the regular opening of the school term in the fall. Out of the incidental or special studies of the summer, the experiences in travel or investigation, or the broadening influences of reaction, every member of the faculty should have something valuable to suggest with reference to the growing problems of the institution and the necessary policies. He who has nothing to suggest as to policy should be regarded as only half a member of the faculty: teaching is not all of university life. Each member of the faculty should feel a share in the determination of policies. All suggestions should be presented in organized form, so stated to secure easy reference to appropriate committees.

These suggestions should be turned over, for analysis and recommendation, to the official committees of the faculty. There should be a large number of these and they should deal with all aspects of the scholastic and social life of the institution. The first few days of the faculty meetings may very well be given over to committee meetings of various kinds. Every member of the faculty should be a member of some official faculty committee, each thus being engaged in helping to work out the official policies of the institution. On the latter days of this week of meetings there should be regular meetings of the full faculty, every man present or accounted for, at which the constructive program of the university year shall be thoroughly considered.

All new suggestions should be carefully gone over in appropriate committees; all new problems considered in full; all the larger needs of the institution fully and freely discussed, both in committee meetings and in appropriate faculty meetings. The result of this week's work of individuals, faculties and committees should be, in the main, the determination of the general institutional policies for the year.

The regular faculty meetings should be for real discussion and deliberation; and it should be distinctly understood that the deliberations are worth something and that the decisions are to become the actual policies of the university, to be really administered by the officials of the institution, within the limits of the university's resources. A large university policy made up of suggestions offered freely by members of the faculty and worked out by the faculty itself in its own corporate meetings will command the loyalty and support of the faculty in a new way; and it will give some excuse for holding faculty meetings.

In addition to all these things, however, there should be a large number of *voluntary committees*, working with the organization and under general control of the university policy, having no authority to bind the university in any specific way, but simply helping in making the university policy successful. Every member of the faculty should be a member of some one of these voluntary committees. These opportunities for university service are unlimited; but there should be such voluntary committees on the following lines, at least:

1. Athletics: There should be in addition to the official committee on athletics a voluntary committee of fifteen or twenty members of the faculty loosely working together *to secure a larger participation* of the student body and faculty alike in athletics and physical education activities of all sorts. This committee should be composed of men and women interested in all forms of athletics and physical education, and it should work with class officers, with fraternities and sororities, and all other sorts of organizations in developing a larger university atten-

tion to intra-university physical education, and especially outdoor sports. It is likely that this should be a faculty-student cooperative committee.

2. On social affairs and social life: One of the constant complaints made in the average university is with reference to the lack of interest on the part of the faculty in the social life of the student body; and it is a more or less disgraceful fact that a very large number of the university students and faculty as well have practically no part in what is ordinarily called the social life. A committee of cordially cooperating faculty-student membership could do very much towards minimizing some of the excesses of social life on the part of some and the unhealthy lack of social life on the part of others. Perhaps the most important part of the committee's work might be the interesting of faculty members in the actualities of the social life of the school. There should be no attempt, of course, to dictate in any sense at all, but only to cooperate in securing to every individual some normal exercise of his social instincts.

3. On student activities: Every student should take part in some non-scholastic enterprise about the school. At the present time some students have too many of these enterprises in their control, while others are probably just to that extent prevented from having any real share in the out-of-school interests of the student body. Such a committee, of course, could make itself officiously offensive, but a committee of teachers who had not enough tact to be helpful in matters of this kind certainly would be made up of men and women who have no business to be teaching. Such a committee should have a large membership and should be organized to help promote all phases of legitimate "student activity" in the university.

4. On religious and moral problems in the university: Our state universities are lacking in their provision for the larger religious and moral enterprises. Officially, perhaps, little can be done by the school; but a volunteer committee, working with student organizations, can do very much to save those organizations from becoming insipid and to secure to the student body some actual participation in the world's treasures of religious culture, and to help them find their vital relationship to the real work of the world along religious and moral lines.

5. On relationships with the state at large: Here is, perhaps, one of the most important opportunities for such volunteer committee work. The committee should be made up of a strong group of men and women who are vitally interested in the problems of the state. The committee might well be a sort of critical directorate and moral support for the university extension work. It should feel perfectly free to criticize that extension work when it does not seem to be getting proper results in its plans for the state; and it should not hesitate to present

plans to the university as to its opportunities in relation to the state.

Doubtless there are other lines also in which volunteer committees of interested men and women could be of equal service to the university, to the student body, and to the state at large, but these are enough to illustrate the possibility involved.

The one point which needs to be made clear is this, that every member of the university faculty ought to have a chance to share in some real way in the determination of the policies of the university, and in shaping its integral social destiny. Otherwise, such members will either dry up into mere scholastic bean-pods in which their knowledge will rattle around, or else they will become disgusted with the bare formalities of the university and resign to go into work that offers larger opportunities for the use of real intelligence.

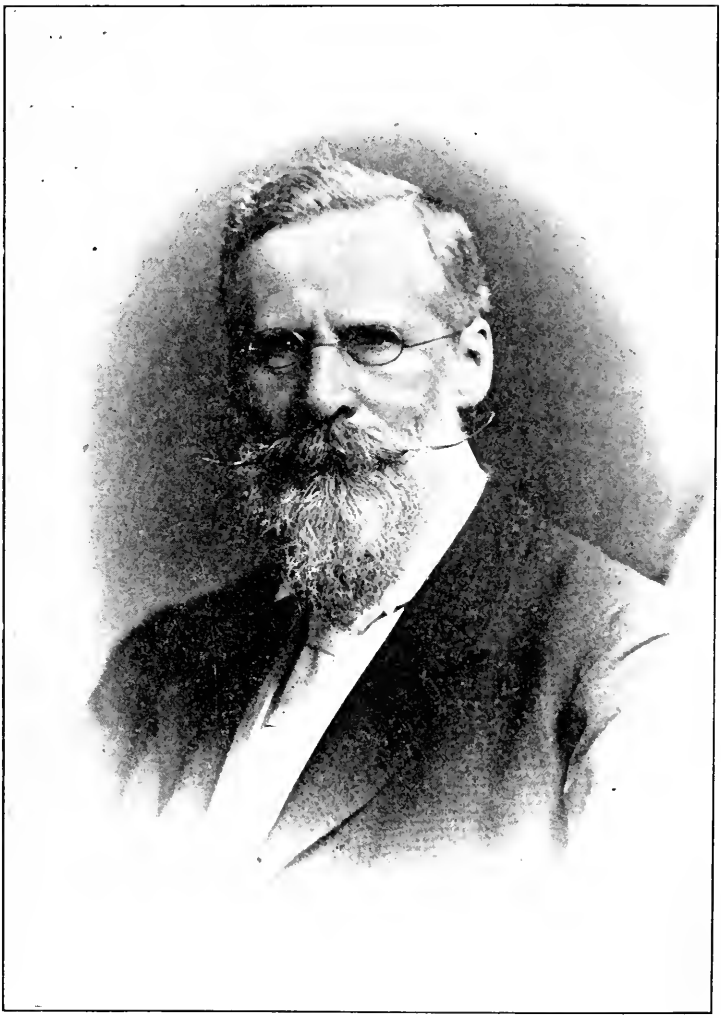
Complaint is often heard that faculty meetings are lifeless and dry. The reason is that the committee work of the average faculty is *monopolized by a few members who take the attitude of dictators of policies*, which the many are expected to follow: these being asked, at stated intervals, to come in from their scholastic duties to vote to confirm the determination of the makers of the policies. The arguments of committee members are usually dogmatic and dictatorial under this system, and the question of the non-committee members are usually scholastic and formal, for they have usually no interest in and little knowledge of the subject.

Now no man can be a real teacher in his class room, in the larger social sense demanded by our modern world, who has not had some share in determining the actual conditions and policies under which that class-room work is conducted. Every man worthy of being a teacher is worthy of having some part in determining the conditions under which he teaches. Every man worthy of having a position in a university at all has some intelligence with reference to the organization and the educational policy of such an institution. In so far as he has such intelligence the state is being defrauded if that intelligence is not called into use in helping to determine policies. Aristocratic conceptions of authority should not blind us to these facts.

Certainly there is nothing more anomalous in all our modern world than an undemocratic character in the very institutions which we boast of as being the training schools of democracy. How such undemocratic institutions fail to train for real democratic living is being shown in the fact of the all but complete failure of the school in relation to democratic living. Certainly the schools, and especially the university, ought to be able to work out processes of real democratic administration within themselves as the chief centers of democratic progress.

Such a plan, as proposed above, with all the corollaries implied but not expressed, is very possible of execution. Not only is it possible, but if our higher education is to be really for democracy, such organization must soon come to be. When it does come it will include much more than is set forth above. Among other things, it will include larger recognition of the fact that the student body is an integral and most important part of the university; and that in all questions affecting the real policy of the university the student body must have a chance to express its deliberate will in a democratic sort of way. But before that chance comes to the student body it is likely that the problem of the democratic participation by the faculty in the actual affairs of the university must be solved.

Doubtless, monarchical, arbitrary, undemocratic ways of doing things will remain longer in the schools than anywhere else, strange as that may seem. But doubtless, even in the schools, there will some time be found enough intelligence to bring to an end such undemocratic survivals from the time of absolute monarchies, and to a beginning the organization of education along lines that will make democracy the very atmosphere of life, in school, out of school, and in all the constructive years that follow school.



Sir William Crookes,

elected to the presidency of the Royal Society.

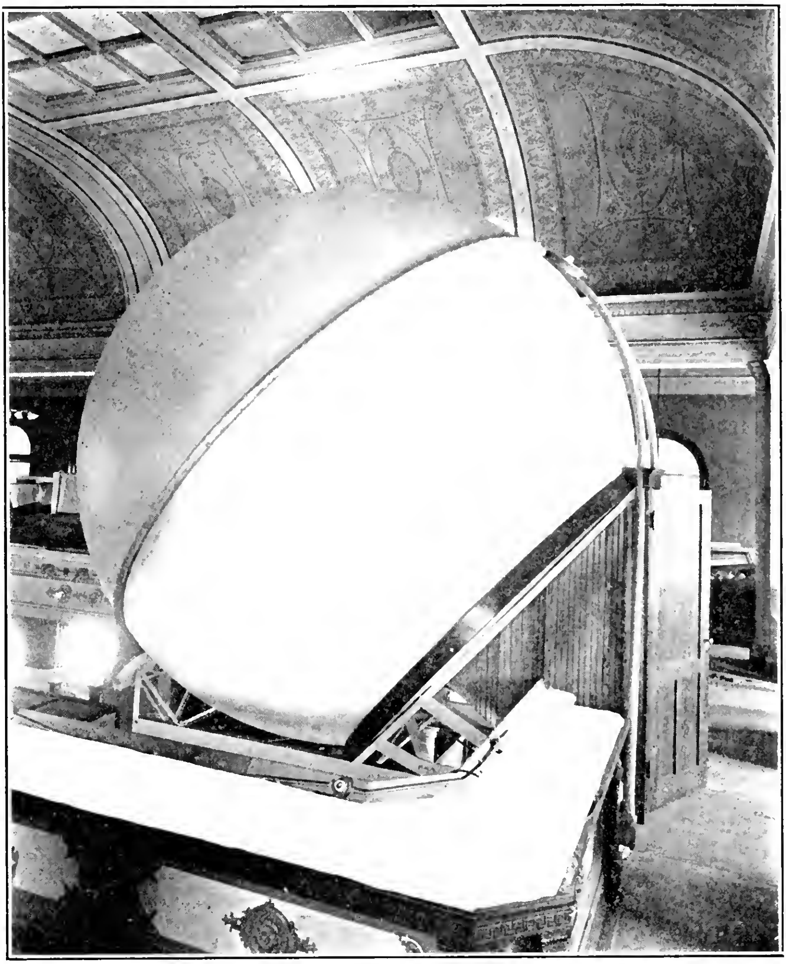
# THE PROGRESS OF SCIENCE

## *THE ANNIVERSARY MEETING OF THE ROYAL SOCIETY*

At the anniversary meeting of the Royal Society held on December 1, Sir William Crookes was elected to the presidency in succession to Sir Archibald Geikie. As a change in this office is made only once in five years, election to it is the highest honor for a British man of science, the immediate predecessors of Sir Archibald Geikie having been Sir William Huggins, Lord Lister, Lord Rayleigh and Lord Kelvin, a roll of scientific distinction which it would be difficult to parallel. Sir William Crookes was born in 1832, and thus belongs to the group of great men of the Victorian era. As long ago as 1862 he discovered thallium, and the weighing of this element in a vacuum led to the construction of the radiometer and to researches on the phenomena produced by the discharge of electricity through the exhausted tubes to which his name has been given. In his theory of radiant matter, he anticipated the electron theory. He has continued his researches with unabated vigor. In his presidential address before the British Association in 1898 he announced the discovery of monium and in connection with his work on the rare earths developed a theory of the evolution of the elements. Even since the discovery of radium he has made important researches, inventing the spinthariscope, which exhibits the results of radium emanation on a screen.

The report of the council and the address of the president review the work of the society. The government gives the society rooms at Burlington House and two grants, one of £4,000 for scientific researches and one of £1,000 for publication. The society is, however, only a trustee to award the grant for scientific research, and, as Sir Archibald Geikie pointed out, the funds of the society are not commensurate with the work it accomplishes. The Catalogue of Scientific Papers, supported mainly by gifts from the late Ludwig Mond, and the International Catalogue of Scientific Literature are expensive enterprises. The tenth annual issue of the International Catalogue has been published, with the exception of the volumes on physiology and bacteriology. A meeting of the International Council will be held in 1914, at which it will be necessary to consider seriously the question of continuing the catalogue. The society received last year the bequest made by Lord Lister of about $45,000 and a gift of $25,000 from Sir James Caird to be used in five yearly disbursements for the furtherance of physical research.

At the anniversary dinner the principal toast, that of "The Royal Society" was proposed by Mr. Page, the American ambassador. He suggested that the explanation of the bankruptcy of great literature might be the rise of science, which had changed all our outlook on the world, and had for the first time made us feel at home in this life and unafraid, had for the moment thrown men of great artistic power somewhat out of the use of their powers. It was a pleasing thought, he said, to suppose that some member of that society, or some similar body, might make a new era by the production of great literature, because the great literature of the future must take account of and must be shaped by the view of life under the dispensation of men of science. Sir Ray Lankester and Sir Harold Dixon responded for the medallists; the former having received the Copley medal and the latter one of the royal



SIDE VIEW OF THE ATWOOD CELESTIAL SPHERE FROM WEST, showing entrance.

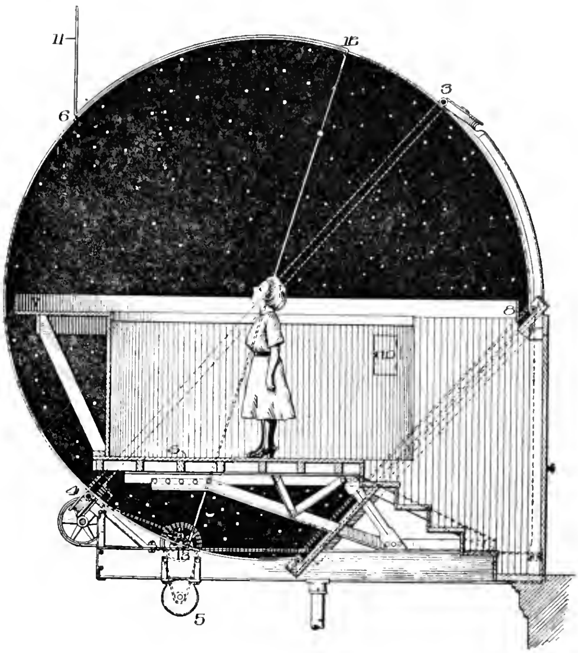
medals. The Huygens medal was conferred on Dr. Alexander Graham Bell, of whom the president said: "His preponderating share in the invention of the telephone, now so long ago as 1876, and his practical investigations in phonetics, have laid modern civilization under deep obligation to him, while his numerous other inventions and experiments show the fertility of his genius."

### *A CELESTIAL SPHERE IN A NATURAL HISTORY MUSEUM*

THE Chicago Academy of Sciences has appreciated the interest in astronomy and the difficulty met in trying to become familiar with even the brighter stars and more commonly known constellations. Various plans for promoting this study were considered by the academy. The flat star charts are confusing to the untrained observer, and the globes on the outside of which stars are sometimes represented are unsatisfactory. To avoid these difficulties the sphere now in the academy building and here shown in illustrations was invented by Dr. Wallace W. Atwood, secretary of the society and director of the museum. It was constructed, installed and presented to the academy by Mr. La Verne W. Noyes, president of the board of trustees, in order to broaden and to promote the educational and scientific work of the academy.

The material used in constructing the sphere is light galvanized sheetiron, which has been pressed to the proper curvature and soldered to the equatorial ring and to a smaller ring about the entrance to the sphere. The platform and horizon table are of wood and rest upon a steel frame. The diameter of the sphere is fifteen feet. The weight, exclusive of the platform, is a little more than 500 pounds. This weight is caried by a $2\frac{1}{2}''$ tube attached to the outside of the sphere along the line of the equator and resting upon three wheels as shown in the cross section view. The two lower wheels carry the greater portion of the weight, but the third and upper wheel, above the door, resists a certain thrust due to the inclined position of the sphere. The stationary platform within the sphere is supported in part by steel trusses resting upon the framework of the museum balcony, and in part by two upright pillars which rest upon the great I beam of the main floor of the museum. This platform carries a circular horizon table, below which the sphere is obscured from view, and above which there is a complete hemisphere on which the stars are represented.

The observer in this sphere is located on the surface of the earth at north latitude 41° 50′. Celestial spheres constructed for localities having other latitudes north or south would be placed at other angles and certain other constellations would be shown. The stars are represented by tiny perforations in the sphere, different sizes being used for stars of different magnitudes. The size




North-south Cross Section of Sphere. 1–2. South Polar Ring at entrance. 3. Upper Wheel supporting sphere. 4. One of two lower wheels which support the sphere and are propelled by motor. 5. Electric Motor. 6. North Pole of the heavens. 7–8. Horizon Table. 9. Observers' Platform. 10. Switch Board. 11. Electric Wire. 12–13. Ecliptic or apparent path of the sun.

and location of each star in the sphere has been determined with great care, so that the sphere is an accurate miniature representation of the heavens. The stars of the first, second, third, fourth and a selected number of those of the fifth magnitude visible from the latitude of Chicago are represented in the sphere, and the total number is 692. The shifting positions of the planets Jupiter, Saturn, Mars and Venus among the constellations have been provided for by a number of openings made to represent the different positions of each of these planets at different times of the year. The openings not in use are very readily covered. The sun is represented by a small electric light which may be moved from place to place along the ecliptic and thus be kept in its appropriate place among the stars. The moon will be represented by a series of small discs cut to represent its various phases and coated with a luminous salt. These discs may be moved from point to point along the orbit of the moon and thus represent that body in its appropriate position in the heavens.

Each star in the sphere has been numbered and star tables have been prepared so that it is simple for one to identify a particular star observed in the sphere or to locate a given star or constellation. Many of the mathematical conceptions necessary for the study of descriptive astronomy which often discourage the beginner are made with this sphere perfectly simple. Any one, including the younger school children, can with its aid become familiar with the chief constellations, their apparent movement, the brighter stars and the real and apparent movements of the sun, moon and planets.

## *SCIENTIFIC ITEMS*

We regret to record the death of Sir Robert Stawell Ball, Lowndean professor of astronomy at Cambridge University; of Sir John Batty Tuke, M.D., lecturer on insanity at Edinburgh; of Dr. Henry Potonié, geologist of the Prussian Geological Survey, and of Dr. Edwin Klebs, the well-known German pathologist.

Dr. Aubrey Strahan has been appointed director of the British Geological Survey and Museum in succession to Dr. J. J. H. Teall, who will retire on January 5.—Provost Edgar F. Smith, of the University of Pennsylvania, has been elected a member of the board of trustees of the Carnegie Foundation for the Advancement of Teaching to succeed Dr. Ira Remsen, recently president of the Johns Hopkins University.

At the meeting of the National Association of State Universities, which was held recently in Washington, D. C., a committee was appointed to draw up plans and policies to be submitted to congress for its approval. A bill will be presented asking for $500,000 as the first step in the organization.

Shortly after the issue of this number of the Monthly the scientific societies will hold their annual convocation week meetings. The American Association for the Advancement of Science meets in Atlanta, beginning on Monday, December 29. With it meet the national scientific societies devoted to astronomy, physics, entomology and botany. The societies concerned with zoology, physiology and anatomy meet in Philadelphia, the geologists in Princeton, the anthropologists in New York, the psychologists and philosophers in New Haven, the economists and sociologists in Minneapolis.

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## THE PHYSICAL LABORATORY AND ITS CONTRIBUTIONS TO CIVILIZATION


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ALTHOUGH physics is one of the oldest and most respectable of the sciences, it must be acknowledged with regret that many otherwise well-educated persons have but a vague idea of its scope, and the question, "What is a physical laboratory and what does one do in it?" is by no means a rare one. The science of physics or natural philosophy, as it was called by Newton, properly includes the study of all natural phenomena that are not concerned with life, as distinguished from biology, which undertakes to investigate the phenomena of living organisms. To speak more particularly, physics deals with mechanics or the phenomena of motion and its causes, including those motions which we characterize as sound; with heat, light, electricity and magnetism and those new phenomena which have to do with radio-activity and the recently discovered new sorts of radiation. It is thus impossible to make any classification of physics which shall exclude astronomy, which is divided into celestial mechanics or the study of the motions of the sun, planets, comets and stars, and the new science of astrophysics, or the study of the physical and chemical constitution of the stars mainly by means of the spectroscope invented only about fifty years ago, or which shall exclude chemistry, which now more than ever before is concerning itself with the relations of different elements and their compounds to phenomena of heat, electricity and light. Geology has mainly to do with the applications of physics to the surface of the earth. Nevertheless, for purposes of convenience it has become customary to divide off these other sciences from physics proper and to have them studied and taught by separate professors.

If we examine the history of physics we shall find that this division came very late, perhaps not much more than one hundred years ago. The first physical phenomena to be studied were, undoubtedly, those of day and night, the rising and setting of the sun and moon, and the changes of the seasons. We know very well that a people as highly cultivated as the Greeks, although they were deeply interested in natural phenomena, had an extremely small knowledge of the laws of nature and had not learned how to investigate them. Although they possessed an excellent knowledge of geometry, they had not the slightest idea of the nature or laws of motion, whether celestial or terrestrial, and with the exception of the properties of the lever and of liquids at rest, known to Archimedes, their knowledge of physics was almost a blank, and yet their great philosopher, Aristotle, dominated science until the sixteenth century of our era. It was at this time that the dawn of modern physics took place with the beginning of the experimental study of nature by Galileo. We must remember that Aristotle suffered not so much from lack of knowledge as from lack of appliances. What might he not have discovered had he possessed a thermometer, a telescope or even a clock! Nevertheless, Galileo did not possess these simple instruments, but he went to work to make them possible. He invented the telescope and thus made possible the searching of the mysteries of the heavens. Although he had no clock, he studied the motions of the pendulum, formed by the great lamp in the baptistery at Pisa, by comparing the time of its swing with the number of beats of his pulse, thus making possible the application of the pendulum to clocks by Huygens. As a contrast of Galileo's method with that of the Greeks may be cited his experiment of dropping a light and a heavy body from the top of the leaning tower of Pisa and showing that both fell to the ground at the same time, instead of believing, as the Greeks had done from reasoning without experiment, that the heavy body falls the faster. By careful study of the motions of a ball rolling down an inclined plane, Galileo was able to enunciate the precise law of falling bodies; that their acceleration is uniform, that is, that in equal times their velocity increases by equal amounts. The way was thus prepared for Newton, who in the next century established the connection of all forces with the accelerations produced by them and was able to enunciate the laws of motion, both terrestrial and celestial, in a form that has not been improved upon to-day, constituting one of the most magnificent triumphs of the human intellect. Passing on rapidly we find at the beginning of the nineteenth century the phenomena of electricity beginning to attract the attention of investigators, while those relating to light had already made substantial progress. All this time there had been nothing that could properly be called a physical laboratory. Discoveries had been made by individual inquirers working generally in such rooms as they had in their own houses with the most meager facilities. We all remember how Newton bored a hole in the wooden shutter of his window in order to admit a narrow beam of light which was to be dispersed into a spectrum by his prism. Even as late as the middle of the nineteenth century the celebrated determination of the velocity of light was made by Foucault, who is said to have been so poor that he was obliged to hire a pair of telescopes at an optician's and to make the experiment in his own rooms. In fact, physical research had reached a very great extension before the provision of special buildings in which to carry it on had been thought of, and these were first provided in connection with instruction. It was not until 1874 that the celebrated Cavendish laboratory was completed at the University of Cambridge, and it is worth remarking that this great laboratory, out of which has proceeded a large number of the most remarkable modern discoveries in physics, was built at a cost of little over $40,000. It is interesting to know that the introduction of laboratory studies at Cambridge was attended with much shaking of heads and it seemed necessary to Maxwell, the first professor of experimental physics there, to justify its introduction in his opening lecture. "But what," he says, "will be the effect on the university, if men pursuing that course of reading which has produced so many distinguished wranglers turn aside to work experiments? Will not their attendance at the laboratory count not merely as time withdrawn from their more legitimate studies, but as the introduction of a disturbing element, tainting their mathematical conceptions with material imagery and sapping their faith in the formulæ of the text-books?" A more amusing doubt was that expressed by Todhunter, himself a distinguished mathematician and student of natural phenomena. "What is the use," said he, "of a student's confirming a physical phenomenon by an observation in the laboratory? If he will not believe the statement of his tutor, who is presumably a gentleman of exemplary character in holy orders, what use can there be in his repeating the experiment for himself?" It is needless to say that this point of view has long since passed into oblivion and the strong point of the laboratory is that it enables the student to himself verify the laws of nature quite independently of the statements of any authority whatever, however respectable.

The purposes of our laboratories then are twofold. First, in them we teach our students the use and manipulation of instruments and the methods for the precise verification of physical laws. In this way the student becomes accustomed to habits of accuracy and the reporting of what he actually sees without the aid of the varnish of imagination and unaffected by any prejudices as to what result he expected to get. We thus have an education in morals which is hard to equal in any other part of education. As a simple example let us consider the method in which the student studies the motion of the pendulum in the elementary laboratory. Instead of measuring the time of its swing by his pulse beats in the manner of Galileo, he compares it with the beats of an accurate astronomical clock, which he perceives by his ear while with his eye he notes the passage of the wire which supports the ball of the pendulum across an accurate mark, thus being obliged to use the senses of sight and hearing at the same time. He must then measure the length of the wire accurately as well as the diameter of the ball which hangs from it. Later on, as there will be difficulty in telling where the string or wire ends, more refined means must be adopted for defining and measuring its length. From the results of these measurements the student will by means of theory be able to calculate the result expressing the intensity of gravity and as he presumably knows the correct value, he will be under a certain temptation to so "doctor" his results as to make his work seem accurate. It is needless to say that such doctoring can never be tolerated and is totally incompatible with the character of a true scientist. The example which I have given shows the nature of almost all the work that is undertaken in the physical laboratory. In every experiment certain data are taken which enable us to give a numerical measure of the properties of certain bodies, or a statement of the numerical relations involved in phenomena. As an example we may take the question of the determination of the specific heat of bodies, that is to say, of the amount of heat required to heat a body through a certain range of temperature. For this purpose the body, say an iron ball, is heated to a certain definite temperature, let us say by being immersed in the steam of a boiler in which water is boiling. The ball is then dropped into a vessel containing a known quantity of water and the heat that it gives out in cooling is measured by the rise in temperature which the water undergoes. This apparently simple process is found to be attended with a great deal of difficulty. In the first place, the determination of the temperature of the ball, when in the steam boiler, is no easy matter. A thermometer immersed in the steam as near the ball as possible may not show exactly the temperature of the ball. Secondly, if the stem of the thermometer is entirely immersed in the hot steam the temperature shown would be different from that when only the bulb of the thermometer is in the hot steam and the stem in the cool air. Thirdly, it will be difficult to transfer the ball from the hot steam to the cold water so quickly that it will not have lost some of its heat, which we want to measure, before it gets into the water. Fourthly, as soon as the temperature of the water in the calorimeter, as it is called, begins to rise the calorimeter begins to lose heat by radiation to outside bodies. In order to estimate this we must first study the laws of such radiation by allowing water previously heated to cool in the calorimeter and observe how rapidly its temperature falls. Finally, it is necessary to know accurately how much water was in the calorimeter, which is found by weighing, but during the whole experiment water is being lost by evaporation. When we consider all these corrections that must be carefully made as well as the fact that to accurately read the height of the mercury in the thermometer it would probably be necessary to look at it with a telescope, the difficulties in this simple experiment and the temptation to slight something are very apparent, and yet this is what we expect a freshman to do in the time of about two hours in the laboratory, and at the same time we expect his result to have an accuracy considerably better than one part in a hundred.

The second and in many cases far more important function of the laboratory is to serve as a place for the performance of accurate research, that is, the investigation and discovery of new phenomena. In order to take part in this inspiring occupation it is obvious that the student must have acquired a considerable amount of proficiency and have already made measurements of a great variety involving a high degree of precision. It is often supposed that scientific discoveries are attended with a large amount of luck, or that they are the result of a sudden inspiration which may come to anybody. Such is far from being the case. Professors of physics are frequently the recipients of visits from persons who in their enthusiasm feel that they have made an important discovery, which in many cases has been thrown off as a sort of by-product in some other vocation. Not many years ago I received a visit from a young man who had traveled over two hundred miles to present to me the results of a theory which he had elaborated to account for the motion of rotation of the planets on their axes. After I had inquired whether he had made himself familiar with the writings of the great masters in celestial mechanics, and had explained to him the impossibility of his theory, I asked him this question, "Do you realize, my dear sir, that if your theory were correct, it would upset the consequences of all the astronomical observations that have been made during the last two hundred years?" The young man went away sadder but wiser and I did not hear from him again. As a matter of fact discoveries are seldom made by persons not possessing the training that I have described, and in ninety-nine cases out of a hundred the element of chance is reduced to the smallest possible dimensions.

I have already stated that the provision of great physical laboratories in connection with instruction is extremely modern. In England the pioneer work in systematized instruction was done in Oxford and London about 1867. The Clarendon Laboratory at Oxford was built from 1868 to 1872, while the Cavendish Laboratory in Cambridge was, as has been stated, not opened until 1874. In this country the first systematic laboratory course in physics was organized about 1870 by Professor E. C. Pickering, at the Massachusetts Institute of Technology, which illustrates one of my points that I have already made, for Professor

Pickering has now been for about thirty-seven years the head of the astronomical observatory at Harvard. The present physical laboratory at Harvard was built in 1884. Of late years laboratories have been built at all our colleges, and there has developed a tendency to make them very large and costly. Two of the latest, the Palmer Laboratory at Princeton and the Sloane Laboratory at Yale, have gone well beyond the quarter of a million mark. The largest and best equipped laboratory in the country is that belonging to the national government, and known as the Bureau of Standards, which, in its brief history of about ten years, has had over two millions of dollars spent upon it. When we consider that this institution is entirely separated from teaching, we must believe that work of great importance is done there to justify this great outlay. Permit me to describe what some of the functions of such a laboratory are, and incidentally to explain some of these devices that are to be found in any great modern laboratory.

At the Bureau of Standards we find five large buildings, each devoted to a particular purpose. These have cost $712,000. In the largest we find the divisions of weights and measures, of heat, and of light. The chief objects of the Bureau of Standards being necessarily practical, the researches undertaken there are limited in scope by this consideration. Nothing is perhaps more practical than the verification of the standards of weight by which commodities are bought and sold. Even the weights of the mint are tested at the Bureau of Standards. Accordingly in a basement room mounted upon heavy brick piers, which are a prominent feature in every physical laboratory in order to secure freedom from vibration, we find extremely accurate balances, some of which are capable of weighing a body with an accuracy of one part in fifteen or twenty millions. The comparison of two equal weights is probably susceptible of greater accuracy than any other physical operation. It is to be remarked that in order to attain this degree of accuracy the balance has to be operated in vacuo, the whole instrument being placed in a case from which the air is pumped out, and all operations of transferring the weights being conducted from a distance by means of controlling rods or shafts, since the heat of the observer's body near the balance would so change the length of the beam as to render such an accuracy impossible.

Next to weighing comes the measurement of length, which is susceptible of about the same accuracy. Here again, the effect of changes of temperature in causing metal scales to expand has to be provided against, so that the work has to be carried on in a subterranean vault, where the changes of temperature are made as small as possible. In the division of heat great practical importance belongs to the measurement of temperatures. Thousands of thermometers of all sorts are sent here yearly to be tested. Before the existence of the Bureau of Standards there was no official means of verifying the accuracy of clinical thermometers used by every physician in diagnosing disease. Here these thermometers are placed, perhaps a hundred at a time, in a bath of water whose temperature is controlled, by thorough stirring, to an equality of temperature of less than a hundredth of a degree. Of great importance is also development of a means of measuring high temperatures, such as those of red or white heat, at which glass would melt. For these high temperatures it is necessary to use a thermometer-bulb of platinum or some more infusible metal, and filled, instead of with mercury, with some gas. For practical purposes, such as the determination of the temperature of furnaces for porcelain, or for the treatment of steel or the annealing of glass, the temperature may be measured by the comparison of the color of the light emitted by the substances in question with that of a filament heated by a known electric current.

In the division of light one of the most important practical matters is the measurement of the intensity of sources of light, particularly of incandescent electric lights, for when one pays a certain amount he desires to get the largest amount of light possible for his expenditure. It is of interest to know that the amount of light obtained for a certain amount of electrical energy has been increased at least ten times in the last few years by the introduction of the filament of the metal tungsten instead of carbon. Another matter of practical importance in the division of light is the determination of the action of quartz crystal and other substances in twisting the so-called plane of polarization of light, since by this property the strength of sugar solutions is measured, and by such tests the rate of duty is fixed that sugar shall pay.

Two large buildings are devoted to electrical and magnetic research. The enormous development of the production of electricity, whether for light, power or transportation purposes, has rendered the exact specification of its standards of measurement of superlative importance. For over forty years such researches have been carried on in many countries, with ever-increasing precision, but still with certain small discrepancies between the determinations of different national laboratories. For instance, the unit of electric current is practically defined by the weight of silver that it will deposit from a solution in a given time. Owing to the discrepancies in the values obtained, the happy idea occurred to Dr. Stratton, the director of the Bureau of Standards, of inviting the national laboratories of England, France and Germany to send each a delegate to the Bureau of Standards in Washington, where each would carry on measurements by his own methods on the same current traversing all the instruments, thus the discrepancies were much reduced and physics was made to contribute to international good feeling. Besides these researches to establish the standards, which we have already seen to be necessary in heat, light and electricity, many tests are required on the properties of materials, such as the magnetic properties of iron that is to be used in dynamo-electric machines. All engineering is but applied physics, and a whole building has been devoted to the testing of materials used in engineering and in manufacturing, such as the strength of steel and iron, of concrete, and other materials used in construction, of thread, paper, leather and textile manufactures. It is known that the government buys all its supplies on specification, and for many of the bureaus the testing is carried on at the Bureau of Standards. In addition the Bureau has two branches, one at Pittsburgh, for testing structural materials, and one at Northampton, Pa., for testing cement, where all the cement used in the Panama Canal is tested. It is easy to see how under this rigid testing many improvements of importance to manufacturers are developed, and in this way industry is largely promoted. In fact the bureau is now of as much interest to manufacturers and engineers as it is to physicists.

I have now said enough to show the direct practical importance to the country of a laboratory in which testing, as well as research, is done, even though no teaching is done there. But when I speak of contributions to civilization I do not by any means limit myself to the increase of human comfort, and to the increasing of the production of wealth. Neither do I consider this as the main object of science, nor its chief justification, although it is one that is most easily apprehended by all intellects. Science does not consist in the observation and classification of facts that are useful in this narrow sense, but rather in the fitting of them into a great and harmonious system, that convinces us of the reasonable scheme of nature, and gives us the same esthetic pleasure that the performance of a great piece of music affords, and lifts our spirits to the contemplation of the author of that great scheme of nature, of which, however much we learn, an infinitely greater amount remains for us still to explore. It is only to those who have personally wrestled with nature in the attempt to make her yield up her secrets that this highest aspect of science is revealed. Fortunate are those who, untrammeled by practical ends or the hope of gain, can devote their lives to the calm, undisturbed questioning of nature, and such should our college professors be. It is not yet generally understood that professors should be paid such salaries that they may take this high view of their calling, without being disturbed and in a large degree prevented from fulfilling these highest duties by the struggle for existence.

I shall now, having described some of the objects and means of research in physical laboratories, attempt briefly to trace the history of one or two notable discoveries of the last quarter of a century, with the results of which at least the public is in a large measure concerned. One hundred years before the present time, almost all that was known of electricity was embraced in the knowledge obtained by the Frenchman Coulomb regarding the law of force with which electricity at rest upon conducting bodies attracts and repels other electricity. Nothing was known of the phenomena of electricity in motion, flowing, as we say, in a current. It was not until 1827 that the law stating the dependence of the strength of the current on the driving-power of the battery causing it was discovered by the German Ohm. But a fundamental discovery was made in 1820 by the Dane Oersted when he found that the current in a wire would act upon a magnet anywhere in its vicinity, or would produce what we now call a magnetic field. Upon this discovery depends the possibility of all our telegraphs, for which the current was soon utilized. But a more powerful intellect than that of Oersted, namely that of the Frenchman Ampère, inspired by Oersted's discovery that a current acted like a magnet, reasoned that in that case two currents would exert magnetic forces upon each other, and in a wonderful series of researches determined the mathematical laws of these mutual actions of currents in the most complete manner. When we see the primitive apparatus with which Ampère made these brilliant discoveries, we are led to have the most profound admiration for his brilliant experimental and mathematical genius, and we may secretly wonder whether we have not laid too much emphasis to-day on fine laboratories and equipments. The next commanding genius that appears on the scene, whose work is more important than any of those yet mentioned, is Michael Faraday, professor at the Royal Institution, a laboratory for research and popular lectures, founded by our own countryman who later became Count Rumford, but made forever famous by the discoveries there made during a long term of years by Faraday. Those who have visited the laboratories at the Royal Institution will be surprised at the total lack at that time of all the conveniences that we today expect, but Faraday was no doubt perfectly satisfied with it. To-day electric lighting and supply of current in a laboratory is a commonplace—then there was not even gas, and all currents had to be made by batteries laboriously filled with chemicals for each time of use. There was no insulated wire, and Faraday had to wind his own with thread or ribbon. Among the greatest triumphs of Faraday was his discovery of the converse of the production of magnetism by electrical current; I mean the production of current by magnetism. After long attempts, he found that if a magnet was moved into, out of, or in the neighborhood of a coil of wire forming a complete circuit, then a current of electricity was induced, as he put it, in the coil during the motion of the magnet. This is the germ of our dynamo-electric machines which to-day supply all the current for our light, power and electric traction. Could Faraday have seen the huge dynamos of ten thousand horsepower each that convey the power of Niagara Falls to regions a hundred miles away, he might feel the enormous importance of the work that he had accomplished to the world at large, but I much doubt whether he would have felt a more lively satisfaction than when he first saw the electric spark jump between the ends of his coil surrounding the magnet. The chief question which interested Faraday during the greater part of his life was the question of action at a distance. How can the motion of a magnet or what amounts to the same thing, the change of current in one coil, cause a current to flow in another coil in a different place. This he explained by some change in the medium surrounding the coils, but it was reserved for another to give the complete explanation. This was Clerk-Maxwell, of whom I spoke at the beginning, who was the chief expounder of Faraday's views, to which he added and which he made precise by his wonderful ability to put them into mathematical form. It was Maxwell's brilliant idea that the medium which is affected by the presence of an electric current is nothing else than the ether which is supposed to convey the waves of light, and it was a result of his theory that the electric and magnetic actions are transmitted through the ether in the form of waves. Not only this, but he showed that the velocity of these electromagnetic waves would be exactly that of light. He then made the startling generalization that light waves possess all the characteristics of electromagnetic waves, and in fact differ from them in no essential way. These ideas of Maxwell, first put forward nearly fifty years ago, have now found universal acceptance, and the whole world believes that light is an electromagnetic phenomenon. But it was a long time before Maxwell's ideas were accepted, especially on the continent of Europe. For Maxwell died in 1879 without ever having demonstrated experimentally that electric and magnetic effects are propagated in waves. This was reserved for another, the German Heinrich Hertz, who in 1887-88 was able to demonstrate the propagation of such effects with a definite velocity, which was found to be indeed the same as that of light.

Hertz's first experiment by which this discovery was made was so simple that it may be described. If we have two metal spheres near enough together a spark will pass between them if they are electrified, but only if the electrical potential or pressure is different for the two balls. If the two balls form the ends of a circuit of wire, the whole may be electrified as strongly as we please with never a sign of a spark passing between the balls, for the whole conductor has the same potential. But Hertz found that if the wire, in the form of a rectangular circuit, was connected with one of the ends of an induction coil producing sparks, each time that a spark passed from the induction coil a spark also passed between the balls of the rectangle. This was always supposing that the connection was made to a point of the rectangle not symmetrically placed with respect to the balls, and Hertz explained the phenomenon by supposing that the current flowed in both directions in the form of a wave, taking longer to go to one ball than to the other, so that there would be a difference of potential between the balls, and hence the spark. This was corroborated by the fact that when the connection to the induction coil was at a point symmetrical to the two balls, there was no spark, for then the wave arrived at both balls simultaneously. This experiment was the first to show the propagation of electric current in the form of waves, and Hertz calculated the time of such a wave running back and forth in the wire as the one-hundred-millionth of a second. The possibility of making such rapid oscillations opened up a whole new field of research, which has been greatly exploited in the last twenty-five years. Not only did Hertz show that the current in a wire was propagated in waves, but he also showed that the electromagnetic effects which are able to induce currents in other wires are also propagated across free space in waves. These waves traverse various obstacles, and are stopped only by conducting bodies. Many persons undoubtedly had the idea that these waves traveling through space might be used for signalling purposes, but it was due to the patience and pertinacity of Guglielmo Marconi that these waves, sent by Hertz a distance of a few score feet, might travel across the Atlantic Ocean and still retain the power of exciting a current in a wire properly set up to receive them. It was only in 1895 that Marconi first began his experiments on electric waves, and in the short time of seventeen years wireless telegraphy has become so important to commerce, not only in connection with the reception of intelligence from ships in distress, but for overland communication in certain remote regions of the earth that last summer a conference was held in London where representatives of over forty nations met to negotiate a treaty for the regulation of wireless communications at sea. I had the honor of being a delegate of the United States government to this conference, and during the five weeks of our proceedings, noting the caliber of the delegates sent by the different governments and the seriousness with which every detail was threshed out in the most diplomatic language, I became vividly impressed with the importance of wireless telegraphy to civilization, and again I thought of the work of Faraday in 1830, Maxwell in 1864, Hertz in 1887, as crowned with a success that they could never have foreseen.

Leaving the domain of electrical waves let us turn to another sensational discovery of seventeen years ago. We have seen that wireless telegraphy had been prepared for by the work of nearly three quarters of a century. In December, 1895, the world was startled by the announcement that Professor Röntgen, of Würzburg, had obtained from vacuum tubes in which an electric discharge was passing a new sort of rays, which, though invisible, would yet affect a photographic plate and also possessed the startling power of being able to pass through many opaque substances, while casting shadows of others. Most wonderful seemed the statement that by these rays the bones of the hand could be seen. Seventeen years later these Röntgen rays are used in every hospital, and reveal the inmost secrets of the body. But this is not their interest to the physicist, but rather the fact that they have opened up a whole field of facts previously unsuspected, so that an investigator ignoring them would to-day be held the greatest of old fogies. How did Röntgen come to discover the X-rays? No doubt there was a certain element of chance. We are told that he had covered the discharge tube, the so-called Crookes tube, with black paper, so that no light should get out from it, and that Röntgen's attention was attracted by the fluorescence, or faint shining with light, of a piece of paper lying on the table, the paper being covered with the salt of barium platinocyanide. But why did this piece of paper coated with this uncommon chemical happen to be lying on the table, and why had Röntgen covered the Crookes tube with black paper? We find that barium platinocyanide was one of the substances that had been investigated by previous investigators as to its fluorescence, and that such paper was a commercial article in Germany. Röntgen must then have suspected that there was some property of the Crookes' tube that would cause fluorescence, so that the presence of this fluorescent paper was not accidental at all. This is then a striking example of what I have before stated. A further one is given by a discovery made the next year in Paris. Röntgen's discovery had set the world on fire, and had given rise to a renewed interest in the subject of fluorescence. Noteworthy among fluorescent substances are the salts of uranium, and these were examined by Henri Becquerel, the third generation of physicists of that name. Becquerel placed uranium salts against a photographic plate wrapped up in black paper, and soon found that the plate was affected, even through the opaque paper. At first Becquerel thought that the uranium had this property only after being exposed to the sun's light, but he soon found that the same properties were possessed by uranium salts that had been formed in the dark, and had never seen the sun. In short these salts are constantly emitting a new sort of radiation, now known as Becquerel rays. Physicists now began to look for other substances than uranium which had these properties, with the result that it was found that uranium-bearing ores were found to contain other substances having the properties in a far higher degree, and at last the Curies were able to separate a new element, which was named radium. The field of radioactivity thus opened up has become an enormous one, and many substances have been discovered having radioactive properties. Here is again an illustration of the impossibility of distinguishing between physics and chemistry, for although Mme. Curie is a chemist, the Nobel prize in chemistry was awarded a few years ago to Professor Rutherford, professor of *physics* at the University of Manchester, England. Time will not permit me to go on with the history of this fascinating subject, but I will only remark that in all the great countries radiological institutes have been founded for the purpose of carrying on researches on the medical applications alone of radioactivity, so that here again we may expect great practical results.

I hope I have now sufficiently shown the nature of the contributions of the physical laboratory to civilization, not only in the practical matters of making life easier and more agreeable, but also in the extension of our intellectual outlook, and the making of life more worth living.

# THE ORIGIN AND EVOLUTION OF THE NERVOUS SYSTEM

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TO the ancients what we designate as personality was a more or less general attribute of the human body rather than an aggregate of functions having a strictly nervous source. In fact Aristotle, who was such an accurate observer and profound thinker in so many fields of biology, denied positively that the brain was in any direct way concerned with sensation and declared the heart to be the sensorium commune for the whole body. To Galen is ascribed the belief that the brain was the seat of the rational soul, the heart the location of courage and fear, and the liver that of love. This distribution of the element of personality over the physical body finds its expression in the common speech of to-day, particularly in relation to the heart, which is widely accepted by the popular mind as the source of the more tender emotions. It was chiefly through the anatomists and physiologists of the early Renaissance that the modern movement, which has tended to limit personality to the nervous system, was seriously begun, a movement which, with the increase of knowledge, has gained support to such an extent that it can now be maintained beyond any reasonable doubt. Human personality is in no true sense the outcome of the non-nervous organs, such as the digestive or the circulatory organs, but is the direct product of the nervous system. This system, to be sure, is embedded among the other organs of the body and the environment thus provided influences profoundly its condition and action, but what is meant by individual personality, acuteness or dullness of sense, quickness or slowness of action, temperamental traits, such as a gloomy or bright disposition, incapacity, shiftlessness, honesty, thriftiness or sweetness, are all, strictly speaking, functions of the nervous organs. Although only the higher animals can be said to possess personality in this sense, traces of it occur in the lower forms and its evolution is indissolubly connected with that of the nervous system. It is the object of this paper to trace in broad outlines the development of those organs which in the higher animals come to be the seat of personality.

The nervous organs of the higher animals, including man, consist of enormously intricate systems of interwoven nerve cells or neurones whose unique character was first fully grasped some twenty years ago by Waldeyer. These neurones, like other cells, possess a nucleated cell-body, the ganglion cell of the older neurologists, from which extremely attenuated processes, the nerve fibers, reach out to the most distant parts of the animal. These processes are the most characteristic parts of the neurone. Extending as they do in the largest animals for some meters from their cell bodies, they afford an example of a cell process such as is seen in no other histological unit. Not only are the nerve cells or neurones thus highly specialized in their structure, but they also exhibit profound physiological differentiation. Thus among the primary sensory neurones each one is connected, as a rule, with a particular portion of the animal for which no other neurone is responsible, and among the motor neurones each one controls a group of muscle fibers not called into action by any other neurone. Hence functional specialization among these elements has come to be so extreme that the nervous system may be described as one in which differentiation has reached to its very cells, a condition that is shown in no other elements of the body except possibly in the reproductive cells.

Notwithstanding the high degree of differentiation exhibited by the neurones of the higher animals, these elements may be easily grouped into relatively few classes distinguishable through their connections. These classes are three in number: first, the afferent, or as they are commonly called, the sensory neurones extending in general from the surface of the animal to the central organs and transmitting sensory impulses; secondly, the efferent neurones connecting the central organs with the muscles, glands, etc., and transmitting efferent impulses; and finally, what may be called the association neurones, to extend to the whole nervous system, a term used by Flechsig for elements in a limited part of the brain, or those neurones which lie entirely within the central organ and connect one part of this organ with another. Although the nervous organs of the higher animals are composed of an abundance of all three classes of neurones, the association neurones in all probability far outnumber those of the other two classes and constitute the chief mass of these organs.

Almost all nervous operations in the higher animals involve all three classes of neurones. The typical nervous reaction of these animals consists of a sensory stimulation followed by a motor response. This operation has been called a reflex, to use that term in its widest sense, that is, irrespective of the association of the action with voluntary or conscious operations. Such a reflex takes place over an arc of neurones, the sensory members transmitting to the association elements, and these in turn to the motor elements, but in describing the reflex its parts are not conveniently dealt with from the standpoint of the neurone. The reflex, as ordinarily understood, begins with the activity of a sense organ or receptor, from which a sensory impulse passes to the central nervous system or adjustor, whence the nervous disturbance makes its way to the third element or effector, usually a muscle. The sense organs or receptors are, for the most part, the distal ends of sensory neurones. The central organs or adjustors include the proximal ends of these elements, all the association neurones, and the proximal ends of the efferent neurones. The effectors are not neurones at all, but muscle fibers, gland cells or other types of cells under the control of nerves. Thus the ordinary reflex may be said to involve in sequence the activity of a receptor, adjustor and an effector, to use modern terminology, and these three elements are recognizable in every complete reflex arc.

Our own reflexes are sometimes associated with consciousness and sometimes not. When we pass from a region of dim light to one of bright light the pupils of our eyes contract without our being conscious of the fact. In a similar way, when food is introduced into the digestive tract, a whole succession of reflex movements is called forth without any direct relation to our consciousness. On the other hand, if we burn a finger, it is usually withdrawn with full recognition of the sensation and the response. Thus a reflex may or may not be association with a conscious state.

From this standpoint, what is the condition in the lower animals? Have they nervous systems composed of neurones and exhibiting reflexes which in some instances are associated with consciousness, and in others not? In other words, what have been the steps by which has developed that mechanism which serves us at once as the means of our simplest reflexes and the material basis for our intellectual life?

As an example of the lower animals whose nervous activities are worthy of consideration we may take the earthworm. This animal has at its anterior end a small brain from which a ventral ganglionic chain extends posteriorly through the rest of its body. It possesses sensory neurones which extend from the skin into the central nervous organ and motor neurones reaching from the central organs to the muscles. The central organ itself contains association neurones. Thus the three classes of nervous cells which occur in man are also represented in the earthworm but with this difference. The association neurones, which in man are relatively very numerous, are in the earthworm comparatively few. Otherwise the essential composition of the nervous organs in these two forms has much in common.

Not only is the nervous system of the earthworm composed of elements essentially similar to those of the higher animals, but it exhibits similar functional relations. The earthworm responds to a large range of stimuli by appropriate and characteristic reactions, and its movements justify the conclusion that its reflex arcs, like those of the higher animals, involve receptors, an adjustor, and effectors.

Whether certain of the reflexes of the earthworm are associated with consciousness or not is a question that can not be answered definitely, since no absolute criterion for consciousness in any organism other than one's self can be given. Earthworms, however, apparently possess some capacity to profit by experience. Within the past year Yerkes has reported on the training of an earthworm which in a surprisingly short time acquired the habit of escaping successfully from a very simple maze. These results, should they prove true for other individuals, suggest a certain degree of consciousness in these creatures as a basis of their ability to learn. It is, therefore, not impossible that certain of the reflexes of earthworms may be associated with conscious states, even though these states may be of a very low order.

But, though the reflexes of the lower animals show some features that suggest consciousness, it is not probable that this state is anything like as characteristic of these simple forms as of the more complex ones. Certainly some of the performances of these more primitive beings have every mark of the unconscious reflexes of our own bodies. Thus bees that have been artificially hatched and have never seen the colony at work make as perfect comb as though they had learned the art by having been co-workers in an established hive. Such bees, moreover, will not only build comb such as they themselves were hatched from, but will shape a queen cell, a form with which they have had absolutely not the least acquaintance in the past. Thus the very complex operation of comb-building in the bee resembles our own unconscious inborn reflexes, such as the constriction of the pupil and the movements of the digestive tube, rather than our voluntary operations, and this is probably true of many of the activities of the lower animals. In fact, it seems fair to conclude that, though such animals as the insects, crabs, and even the worms, possess a nervous system composed of elements similar to those in the higher forms, their reflexes are much more mechanical and less associated with anything that can be called a conscious state than are those of the higher forms. In other words, these lower animals are more in the nature of reflex machines than are the higher forms, though they are not, as some investigators would have us believe, exclusively so.

But if the nervous system in many of the lower animals is composed of elements similar to those in the higher forms, and exhibits activities not unlike our own, are there not still more primitive animals in which this system shows a real reduction and exhibits a condition which marks the actual beginnings of nervous organization? Such primitive forms have long been supposed to exist among the cœlenterates and are well represented by the sea-anemones.

Sea-anemones are sack-like animals with a single opening leading into the digestive cavity and serving both as mouth and anus. This opening is usually surrounded by a cluster of tentacles. The living body of the sea-anemone consists of the thin membranous wall that separates the digestive cavity from the outer sea-water, and that is drawn out in processes to form the hollow tentacles. In no part of its structure is the sea-anemone massive, as is the case in most higher forms, where the muscles, skeleton and so forth usually give rise to a considerable thickness of tissue; in fact, the animal exhibits no well-defined organs except the digestive organs, and may be described as a membranous digestive sac.

Although the body of the sea-anemone is really nothing more than membranous walls, these walls have long been known to contain both nerve and muscle. These two tissues occur over almost the whole animal. According to the Hertwigs, the nervous tissue is more abundant in the neighborhood of the mouth than elsewhere, and this region has been regarded by some investigators as a central nervous organ. But the studies of Jordan and others have shown conclusively that this opinion is not correct, and that the removal of this region interferes in no serious way with the reactions of the animal. Apparently each part of the sea-anemone carries with it its own neuromuscular mechanism, a condition well illustrated by the tentacles. These organs are chiefly concerned with appropriating the food and are stimulated by the dissolved materials in the food. A tentacle when cut off from a sea-anemone and held in sea-water can still be stimulated by food and will exhibit almost exactly the same kind of movements when thus isolated that it did when a part of the whole animal, thus demonstrating the completeness and independence of its own neuromuscular mechanism. Nervous transmission can be accomplished from almost any part of the sea-anemone to almost any other part, but as such experiments as those with the tentacles indicate, no one part of the animal's nervous organization seems to be more important than any other part. In other words, the nervous system in the sea-anemone is diffuse rather than centralized.

When the minute organization of the nervous system of these animals is studied, it is found to consist of a vast number of sensory neurones which connect the surface of the animal with the underlying muscles and which form there what appears to be an intricate nervous network. This nervous mechanism is concerned primarily with the reception of stimuli and the immediate excitation of the muscles. The nervous mechanism is a receptor mechanism that acts as a trigger for setting off the muscle. The whole neuromuscular apparatus seems to be made up of those two elements which in the higher animals were designated receptors and effectors and without the intervention of an adjustor or central nervous organ. Viewed from the standpoint of development, this condition points indubitably to the conclusion that the central nervous organs were evolved only after the appearance of sense organs and muscle, and that such animals as the sea-anemone may well be taken to represent this step in the evolution of the nervous system. This general view of the origin of the central nervous organs was advanced as early as 1886 by Kleinenberg and was reaffirmed ten years later by Rakowitza.

The evolution of nerve and muscle, so far as this problem can be attacked in such lowly form as the sea-anemone and other cœlenterates, is a question about which there has been much difference of opinion. As early as 1872 Kleinenberg showed that in the fresh-water cœlenterate, *Hydra,* there were certain peculiar T-shaped cells that he called neuromuscular cells and that he believed to represent both nerve and muscle. In these cells the arm of the T reached the surface of the animal and was thought by Kleinenberg to act as a nervous receptor; the cross-piece being contractile was known to be muscle. Kleinenberg assumed that the division of such cells and the differentiation of their parts were the processes which gave rise to the nervous and muscular tissues of the higher animal. In 1879 the Hertwigs in their account of the structure of sea-anemones showed that the so-called neuromuscular cells of Kleinenberg were in reality simply epithelio-muscle cells and were without nervous significance. These investigators, in opposition to Kleinenberg, advanced the view that nerve and muscle, though simultaneously differentiated, were derived from different groups of cells. According to both Kleinenberg and the Hertwigs nerve and muscle were simultaneously evolved, but Kleinenberg maintained that these tissues came from a single form of cell, the Hertwigs that they arose from separate kinds of cells.

My own studies on the origin of nerve and muscle have led to rather different conclusions from those summarized in the last paragraph. In studying the reactions of one of our common sponges, *Stylotella,* I was impressed with the extreme slowness with which the animal responded to a stimulus. The oscula of this sponge can be made to close by the application of several kinds of stimuli. The closure of these openings is accomplished by the contraction of the ring of muscular tissue surrounding them. This response occurs some minutes after the stimulus has been applied, a condition in strong contrast with the quick reactions of such animals as sea-anemones. These forms respond to most stimuli within a second or so, the sponges only within minutes. Moreover, in sponges transmission from the place where the stimulus is applied to the responding muscle is possible only over very short distances and is carried on at a very slow rate. Transmission in *Stylotella* resembles very closely the kind of transmission seen in ciliated epithelium. The successive beat of the cilia is dependent upon an impulse which progresses from cell to cell in the epithelium at a relatively slow rate and is neither purely mechanical nor nervous in its method of propagation. It probably represents a primitive form of protoplasmic transmission, a forerunner of the true nervous impulse, and as such gives us some insight into the nature of the non-nervous transmission in sponges. The results of my studies on *Stylotella* support the conclusions of most biologists who have worked upon sponges, that these animals probably possess no true nervous tissue. Their muscles, in my opinion, are brought into action almost entirely by the direct effect of the stimulus rather than through nerves, and this accounts, I believe, for their very slow response to external disturbances. It is possible that in certain sponges some form of nervous tissue may be demonstrated eventually, or that such organs as those described by von Lendenfeldt as synocils may be shown to have a sensory significance, but such cases, if they do occur, will probably remain exceptional, for as a whole sponges seem to be a group of animals almost if not quite devoid of true nervous tissue. Granting this conclusion, it must be evident that the condition in sponges throws a very important light on the question of the origin of nerve and muscle. Their state suggests at once that nerve and muscle have not been differentiated simultaneously, as maintained by Kleinenberg, the Hertwigs, and others, but that muscle preceded nerve in its evolution and that sponges represent animals with effectors but without differentiated receptors. If then it may be claimed that phylogenetically the sense organ preceded the central nervous organ, it may also be maintained that muscles preceded sense organs. Thus the three elements of the reflex arc of the higher animals were probably evolved separately and in the order, effector, receptor, adjustor.

If muscle originated before nerve and was brought into action at first by direct stimulation, it is natural to expect that examples of this form of response might still be found among the higher animals. And such seems to be the case. Thus the sphincter of the iris in the lower vertebrates, though well known to be under the influence of nerves, was shown by Steinach some time ago to be directly stimulated by light, a condition which, judging from the more recent work of Hertel, probably applies even to the human eye. This muscle then exhibits a certain capacity for normal direct stimulation. Another example of the same kind is seen in the embryonic vertebrate heart. Though the beat of the adult heart may be a matter of controversy from the standpoint of the myogenic and neurogenic theories, there can be no doubt that the muscle of the embryonic heart beats, as shown by His, before it has become invaded by nerves. And this view is supported by Barrow's recent discovery that the isolated cells of the heart-muscle will contract rhythmically under conditions where not the least vestige of a nerve can influence them. Thus the embryonic heart-muscle and the sphincter of the iris are muscles whose activity may be normally called forth by direct stimulation, a condition which reproduces, so far as independence is concerned, the state met with in the muscles of the sponges. These examples then show that even in the higher animals certain muscles respond normally to direct stimulation and thus exhibit a form of activity which is believed to be generally characteristic of sponges.

In my opinion the simultaneous origin of nerve and muscle can no longer be maintained. Muscle arose first and the simple effectors thus produced were the first element of the neuromuscular mechanism. These effectors were directly stimulated and consequently slow in action. They afforded centers around which nervous tissue first differentiated in the form of sense organs or receptors whose function it was to serve as triggers to initiate muscle action quickly. As these receptors became more highly developed, a third element, the central nervous organ, arose from the nervous elements between the receptor and the effector. This organ, the adjustor, served as a means of conducting and modifying the sensory impulses on their way from the receptor to the effector and ultimately it also served as a storehouse for the nervous experience of the individual and as the seat of its intellectual life. It is interesting to observe that this view of the origin of the nervous system is in accord with the philosophical speculations of Bergson according to whom the nervous system has been evolved primarily as an organ for animal response and only secondarily as one concerned with intellectual activities.

But if we picture the nervous system as having arisen as an appendage to the musculature and as having grown in complication as the musculature became differentiated, we are still far from an adequate view of even the more obvious aspects of its evolution. The nervous system controls many more kinds of effectors than muscle and its sensory elements are vastly more complex than is implied in the preceding sketch. To gain a more comprehensive view of the evolution of these organs, it is necessary to consider a subsidiary but important process, the appropriation of effectors and receptors.

The nervous system of many of the higher animals not only acts upon the musculature; it may also control electric organs, luminous organs, chromatophores, glands, etc. Not all such organs are under the influence of the nervous system, but it is not difficult to find for each group of effectors animals in which the given type of organs is under the influence of nerves. The electric organs and the chromatophores of fishes, are of this kind as well as the salivary glands of the mammals and the luminous organs of the brittle stars.

How has the nervous system gained control over these organs? Except the electric organs, which are probably modified muscle, all these organs have arisen in my opinion as independent effectors. Most of them can be identified as such in one group of animals or another. Thus among the glands the pancreas in the higher vertebrates has been shown to be in its action essentially non-nervous. Such highly differentiated, but independent effectors have, I believe, been appropriated from time to time by the nervous system in that during ontogeny certain motor fibers, instead of becoming attached to their appropriate muscles, have wandered to new effectors which have been sufficiently responsive to their stimuli to give a basis for a permanent attachment. Thus the nervous system, once established around muscles, has widened its influence in that it has appropriated other types of independent effectors, which upon application were found to be responsive to its stimulus.

But the differentiated nervous system has not only extended itself on the side of its effectors, it has probably also made receptor appropriations. This is well illustrated by several groups of related sense organs such as the organs of touch and hearing in the vertebrates or those of the chemical senses in the same animals. The latter may serve as an example.

The chemical sense organs in vertebrates include not only those of smell and of taste, but also the organs of the common chemical sense such as are concerned with the chemical irritability of the skin of the frog or of the exposed or semi-exposed mucous surfaces of man. All these chemical receptors are stimulated by solutions. In taste the stimuli are the dissolved materials in the food; in smell they are the solutions formed on the moist olfactory surface from the materials wafted in the air to the nose.

The neurones concerned with the reception of these stimuli exhibit interesting relations. The olfactory neurones, as is well known, have their cell bodies in the olfactory epithelium, whence their neurites extend into the central olfactory apparatus. They reproduce in a most striking way the type of primary sensory neurone common to the invertebrates, and in this respect they represent the most primitive type of sensory neurone in the body of vertebrates. The neurones concerned with the common chemical sense are like those of the olfactory sense except that their cell bodies have migrated centrally and constitute a part of one of the cerebro-spinal ganglia. As a result the distal ends of these neurones are represented as free-nerve terminations in the epithelium of the moist parts of the vertebrate skin. The gustatory neurones reproduce almost exactly the condition of those of the common chemical sense, except that their distal free terminations are around taste buds instead of being in an ordinary epithelium.

The conditions shown by these three types of receptor mechanisms suggest at once a genetic connection. The olfactory type is undoubtedly the most primitive, and stimulation in this instance is initiated by the chemical action of the superimposed solution on the hairs of the olfactory cells. The neurone for the common chemical sense has probably been derived from one of the olfactory type by a proximal migration of its cell body. The stimulation of its free-nerve terminals may be conceived to take place, as Botezat has recently pointed out, through the secretory activity of the surrounding epithelial cells as a result of their contact with the stimulating solution, rather than from the direct action of this solution on the nerve endings themselves. From this standpoint the epithelium comes to be an essential element in the stimulation of the neurone and affords, so to speak, a favorable sensory environment for the real nerve-endings. Finally, the gustatory neurones may be said to have appropriated certain of these epithelial cells which have become differentiated into taste buds and whose activity, probably secretory in character, to follow Botezat, is called forth by the superimposed solution and is essential to the stimulation of the nerve endings.

Thus in the evolution of the chemical sense organs of vertebrates certain integumentary cells originally quite independent of the receptors came to be involved with these and were eventually appropriated by them as essential parts of the gustatory apparatus. This process of appropriation is not unlike that seen among the effectors and represents one of the important steps by which the nervous system in the course of its evolution has added to its complexity. Although the nervous system probably arose in a scattered way at spots where the primitive multicellular animal had developed muscle, it became unified through the need for general transmission tracts, and, by increasing its own elements as well as by appropriating additional effectors and receptors, it has impressed upon the higher animals, including ourselves, a unity so profound that it includes everything that we mean by personality.

# CURRENT PROGRESS IN THE STUDY OF NATURAL SELECTION

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## I. Introductory Remarks

In papers on "The Measurement of Natural Selection" and "On Assortative Mating in Man," which have appeared in these pages,[1] I have endeavored to show by a review of the quantitative work already done that natural selection and sexual selection are not subjects for idle speculation and polemics, or even for inductions from comparative evidence, but that, like the other factors of organic evolution, they are open to direct quantitative investigation.

It is perhaps not too soon to list up for the convenience of those who desire to take a broad view of evolutionary research, the studies in natural selection which have appeared since the first of these papers was written.

In doing this the ideals of the earlier papers will be carefully maintained. That is, only questions of observed facts and the methods of analyzing them will be taken into account. Theories will be ignored. Again, both positive and negative results will be given impartially, for in the real advancement of science both are of importance in the direction of research and in the formulation of laws.

It will be conducive to clearness to recognize that two fairly distinct problems confront the student of natural selection. The first is to determine whether in any given case the death rate is random or selective. The second is to ascertain what physical, physiological or psychological characteristics make for fitness or unfitness for survival. The attack upon the second problem presupposes the successful solution of the first, for if there be no evidence of the selective nature of the death rate, it is obviously idle to test the selective value of individual characteristics. It is equally clear that any study which stops short of the second of these tasks is in a high degree unsatisfactory. From the standpoint of evolutionary science it is desirable that the significance for survival in various environments of each type of variation in structure or function should be worked out. But this is a task of the highest difficulty and will probably never be accomplished for more than a few selected cases. In these exceedingly difficult fields practicability must be a primary consideration. In many cases, it may

[1] Pop. Sci. Mo., 78: 521–528, 1911; *loc. cit.*, 80: 476–492, 1912.

be quite out of the question to do more than determine whether the death rate is selective or random, and in such cases these first steps may be of very high importance indeed. Again, it may be feasible to plunge at once into the second problem by testing the value of character after character in the battle for life. In this case both phases are simultaneously taken up. These points will be made clear by illustrations.

## II. Further Attempts to Ascertain whether the Death Rate is Selective and to Determine the Intensity of Selection

The first problem to be taken up is therefore that of the existence or non-existence of selective mortality. In a considerable range of living forms it is desirable to know whether natural selection is operative, even though it is for the time being out of the question to say how it is operative, *i. e.*, what particular characteristics make for incapacity or for fitness.

### A. *The Simple Demonstration of the Existence of a Selective Mortality*

*Studies on Plants.*—A first illustration of the importance of the simple determination of the selective or non-selective nature of the death rate is to be seen in the cases of the northward extension of cereals or other cultivated plants. At present, very little is definitely known concerning the factors actually involved. It has been frequently assumed that natural selection through the agency of cold or of the shortness of the growing season has been one of these. This view seems to be supported by Waldron's[2] work on alfalfa. He shows that some strains are more resistant to cold than others, and that in the north the less resistant are eliminated. This is all that is necessary to bring about adaptation—which already exists in some strains.

Another most interesting piece of work differing widely in material and detail, but depending upon the same kind of reasoning, is that of Montgomery.[3] Our common cereals have been cultivated for hundreds or thousands of years with practically no attention to selection or grading until recent times. He suggests that under the system of planting two or three times as many seeds as can possibly come to maturity, a slow development has taken place through a continuous natural selection with the survival of the strongest.

He has several interesting results for competition, but his most conclusive experiments for selection are those with maize.[4] Planting

[2] L. R. Waldron, "Hardiness in Successive Alfalfa Generations," *Amer. Nat.*, 46: 463–469, 1912.

[3] E. G. Montgomery, "Competition in Cereals," *Bull. Neb. Agr. Exp. Sta.*, 127, 1912.

[4] E. G. Montgomery, *loc. cit.* Also "Thick and Thin Planting for Growing Seed Corn," *Bull. Neb. Agr. Exp. Sta.*, 112: 28–30, 1909.

continuously at the rate of one, three and five seeds per hill[5] for six years, he finds the yields given in the accompanying diagram, 1. Apparently the seed grown under competition yields higher than that grown under thin planting.[6]

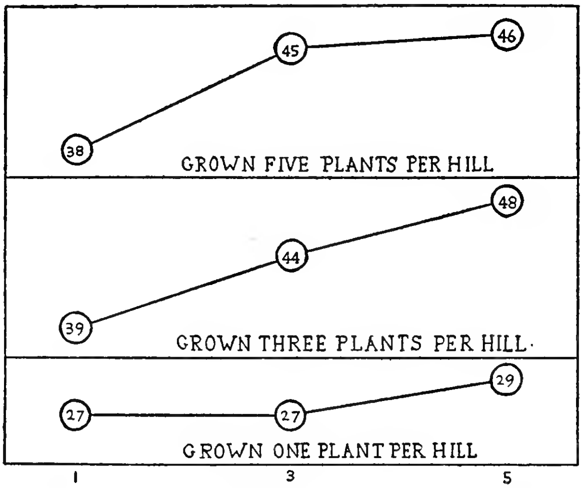



DIAGRAM 1. YIELD OF MAIZE FROM VARIOUS TYPES OF SEED.

*The Selective Death Rate in Man.*—Beyond all doubt the most important work on the question of the existence of a selective death rate has been done on man. This is true not merely from the standpoint of the critical nature of the investigations and the soundness of the conclusions, but from the sociological importance of the findings as well.

The pioneer work of Pearson and Beeton[7] already mentioned in these pages has recently been supplemented by the studies of Ploetz.[8] However conclusive these studies may be, it is most important to have light on this question from another angle. Precisely the information needed should be obtainable in the following manner.

If natural selection be a reality, then (other factors being rendered

[5] When planted at the rate of one per hill about 25 good ears weighing 12 ounces or more are produced to every 100 plants. With 3 plants per hill there are only about 10 good ears, with 5 plants, only about five. A plant capable of producing a good ear with four others in the same hill must be unusually vigorous, but in thin planting it is not possible to tell which of the plants would have been capable of reaching the high standard under keen competition.

[6] The details given in Montgomery's paper are entirely too meager for a problem of such great complexity.

[7] POP. SCI. MO., 78: 533–534, 1911.

[8] A. Ploetz, "Lebensdaur der Eltern und Kindersterblichkeit. Ein Beitrag zum Studien der Konstitutionsvererbung und der natürlichen Auslese unter den Menschen," *Arch. Rass.- u. Gesellschaftsbiol.*, 6: 33–43, 1909.

constant) the survivors of an infantile population subjected to environmental conditions making for a high death rate should in later years show a lower mortality than the survivors of a population subjected to less stringent conditions of life.

*The Possible Selective Element in Infant Mortality.*—That the preservation of the weaker children may result in a population of adults below the maximum physical fitness is an idea as old as the study of Spartan history. The wide acceptance of the Darwinian theory and the modern reduction in the death rate—accomplished largely by the saving in the early months of life—have combined to give it considerable prominence in recent years.

To solve the problem one must find a series of districts[9] differing as much as possible in the mortality of the early months of life, and determine whether those which have a lower mortality in infancy have a higher proportion of men unfit for military service or a higher adult mortality.

Such attempts have been made, for instance, by Rahts, Kruse, Gruber, Koeppe, Prinzing, Elben and others. The indeterminateness of these studies is apparent not only from the discordant conclusions but also from the obvious inadequacy of the statistical technique.[10]

To Yule[11] and Snow[12] belongs the credit of having first applied the modern statistics to this problem. Yule's data and methods, however valuable they may be from the standpoint of the relationships between the mortality of early and later life in a series of districts, seem quite inadequate to the solution of the problem of the selective or non-selective nature of infantile mortality.[13]

A first great merit of Snow's laborious study is that he fully recognizes the multiplicity of disturbing factors and has attempted in as

[9] Snow (see below) is quite right in insisting that the question as to what proportion of the general death rate is selective should be answered on national mortality statistics. From the point of view of evolution, or of sociology, such data are of far more value than the more complete records which can be secured in individual pedigrees, for to be of evolutionary or of national social importance the intensity of the selective death rate must be measured on a perfectly general population.

[10] Examples are given in subsequent footnotes.

[11] G. U. Yule, "On the Possible Selective Influence of Mortality in Infancy on Mortality in the Next Four Years of Life," Supplement to the Report of the Medical Officer of the Local Government Board (Great Britain), 1910, Cd. 5,263.

[12] E. C. Snow, "The Intensity of Natural Selection in Man," Drapers' Co. Res. Mem. (Univ. Coll., Lond.), Stud. Nat. Det. 7, p. 43, London, Dulan & Co., 1911.

[13] This is clear from the criticisms brought forward by Snow. Practically as much has been admitted elsewhere; see *Jour. Roy. Stat. Soc.*, 75: 133–135. In his study Yule shows a caution in interpretation of results which is not as evident in the main body of the medical officer's report.

far as possible to correct for them. His method may be described as follows:

The mortality of children born in any year, say 1903, in as large a series of districts as possible[14] is followed year by year. Working with this series which is *homogeneous with respect to year of birth*,[15] the problem to determine whether, allowing for environmental influence, the death rate of, *e. g.*, the first year, or of the first two years, has any influence upon that of subsequent periods of life.

Now this factor, which for convenience we have designated as environmental,[16] is of great importance. The death rate differs widely from district to district, and in response to many factors.[17] Thus *absolutely* districts having a low mortality for the first year of life might have a low mortality for the second to the fifth years of life; districts having a high death rate for the first twelve months of life would also have a high death rate for the thirteenth to the sixtieth month of life, since many of the causes operating in the two cases (bringing about high or low death rates) affect both age periods.

Thus a high mortality of infancy does not necessarily imply a low mortality of childhood or a high military efficiency. This is true because any influence of selection is largely obscured by such factors as ethnic or social composition or physical environment in the various districts. Before one can say anything at all concerning the possible

[14] It is very important that the subdivisions be as numerous and as homogeneous within themselves as is consistent with data for trustworthy death rates. For, obviously, the death rate in one district in a given year may be abnormally high (or low) because of purely local and transitory conditions. These are precisely the factors which make for a high or low selective death rate. By lumping a number of districts together one may cancel out the very terms he is seeking to investigate! The value of some of the published work is nullified by the neglect of this point.

[15] Obvious as the importance of this point is, it has been entirely overlooked or disregarded by some. To determine that the death rate of children 0 to 1 year of age and that of those 1 to 5 years of age in a series of districts are correlated for a given year, say 1905, proves nothing at all concerning a selective death rate. The infants exposed to conditions (in the various districts) resulting in high and low death rates for their first year of life in 1905 are being compared with those exposed to the action of selection under what may have been widely different conditions in 1904, 1903, 1902 and 1901. The whole factor of the variation in mortality from year to year due to epidemics, meteorological conditions, economic changes, etc., is thus left entirely out of account.

[16] Local influence might have been a better term, since racial composition as well as environment may play a part.

[17] The fact that the death rate is to so great extent within the control of the sanitary and charity boards is sufficient general evidence for this statement. A quantitative demonstration is seen in the fact that a correlation is found between, *e. g.*, the birth rate and infantile mortality; also between artificial feeding rate and infantile mortality. See Greenwood and Bevan, *Jour. Hyg.*, 12: 5–45, 1912.

selective nature of the death rate at the beginning of life he must make due allowances for these factors.

Snow attempts to correct for this environmental factor by using the deaths other than those for the infants born in the particular year under consideration as a measure of the stringency of its influence. The precise manner in which this is done need not concern us here, nor is it necessary to explain in detail the various ways in which the mortality of the first years of life was split up into earlier and later periods in order to ascertain what influence, if any, excessive mortality in the earlier period has upon the chances of survival in the later. Indeed, to discuss adequately all of the difficulties encountered and the highly complex methods by which they were largely overcome by Mr. Snow would treble the space which may be devoted to his research, and transform a review intended for the layman into a discussion comprehensible only to the trained statistician.

For present purposes, it is sufficient to say that (correction being made for environment), those districts in which the mortality for the first period was high had in general a low mortality in the second period.[18] Thus in the long run a high mortality in childhood follows a low mortality in infancy; low mortality in childhood follows high mortality in infancy—remembering always the correction for environmental factors which may hide the action of selection.

Natural selection, in the form of a selective death rate, is strongly operative in man in the early years of life.[19]

M. Greenwood and J. W. Bevan, "An Examination of Some Factors Influencing the Rate of Infant Mortality," *Jour. Hyg.*, 12: 5–45, 1912, find some evidence of the selective nature of infantile mortality in the Bavarian data of

[18] All of Snow's results are not concordant. There are good reasons for believing that some of the series of public statistics analyzed by him are inadequate for so complex and delicate a biological problem as that of selective mortality. Those series of data which biologically and statistically may be regarded as most suitable and trustworthy evidence the most strongly in favor of the selective nature of infantile mortality.

One's confidence in Snow's own interpretation of his results is strengthened by the fact that he has laid all his evidence—that which goes against his own general conclusions as well as that which supports his view—before his reader, believing it to be "more in accord with scientific spirit that the reader should be allowed to draw his own conclusions from the whole of the research, and to form his own opinion on the value of the material used and of the results deduced from it." It is a great pity that such merit should be so distinctive as to require comment, but to-day there is a most unfortunate tendency, among biologists at least, to pigeonhole the *contra* and publish the *pro*. Thus current and popular theories are often for a time bolstered up, when if all of the facts were brought forward their standing would be much less secure.

[19] The reader who goes thoroughly into these problems will read an editorial criticism of Snow's paper in *Jour. Roy. Stat. Soc.*, 75: 133–135, 1911; also the reply by Snow in *Biometrika*, 8: 456–460, 1912, where the criticisms seem to be fully met.

Groth and Martin, but they justly emphasize the great difficulty of the task and the need of wider and better statistics.

### *B. The Selective Value of Particular Characters*

Whenever possible students of natural selection have plunged at once into the problem of the way in which elimination takes place. When only the normal mortality is found for individuals with a given character, or intensely of the given character, selection is there inoperative; when a higher mortality is demonstrated, selection is tending to weed it out; when a lower mortality exists, natural selection is allowing it to gain ground in the struggle for existence. In the following paragraphs the results secured in this field are set forth.

*Seed Weight and Mortality.*—Among flowering plants, the highest death rate occurs in the seedling stage, just as among animals the force of natural selection is well nigh spent by the time a given generation reaches maturity.

It seems most important, therefore, to inquire what influence, if any, the characteristics of the seed or of the plant from which it was harvested have upon its viability. Closely correlated with, but quite distinct from, this problem is that of ascertaining what weight the morphological or physiological characteristics of the young seedling has in determining its chances of survival. It is only recently that these promising fields have been entered.

Consider first the visible characteristics of the seed itself. Montgomery[20] in addition to his studies on competition in cereals, has investigated the survival of plants from small or undeveloped as compared with that of large plump seeds of wheat and oats when planted in competition.[21] He finds that when each kind is planted alone a slightly higher percentage of plants is harvested from the large, well-developed seeds. Thus there is a considerable difference in the original quality of the seed. When planted in (inter-varietal) competition there is apparently a still further advantage in the large seeds. But it appears to be very slight indeed.

> It seems that there are almost as many weaklings susceptible to the effect of competition among the plants from large seed as among those from small seed.

As far as I am aware[22] the only comparable studies have been made on garden beans.[23]

[20] E. G. Montgomery, "Competition in Cereals," *Bull. Neb. Agr. Exp. Sta.*, 127, 1912.

[21] Unfortunately, an intra-varietal competition test for seeds of the two kinds could not be made. The large and small seeds were alternated in the row. To distinguish the two at harvest time it was necessary for them to be of different varieties. Inter-varietal competition probably introduces some factors not present when all the individuals are of the same strain.

[22] The literature of seed testing is very large and much attention has been given to the produce of large and small seeds. Practically all the work has been

In these experiments the seeds were all carefully examined to make sure that they were perfectly developed[24] and differed only in size.[25] The biometric constants of 28 series which developed into mature plants have been compared with those for the original series of seeds from which the plantings were drawn.[26]

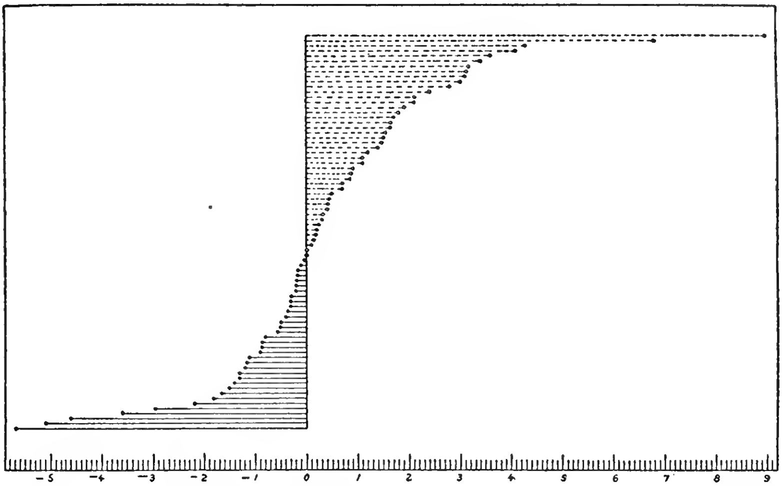



DIAGRAM 2. DIFFERENCES IN MEAN WEIGHT OF GENERAL POPULATION OF SEEDS AND OF THOSE WHICH PRODUCE PLANTS. All differences are reduced to a percentage basis.

The results of these studies can be most conveniently presented graphically. To demonstrate more clearly to the eye the existence of a

done on too small a scale to be conclusive. Possibly among these writings some records of the viability of seeds of different sizes may be found.

[23] J. Arthur Harris, ''On Differential Mortality with Respect to Seed Weight Occurring in Field Cultures of *Phaseolus vulgaris,*'' *Amer. Nat.*, 46: 212–225, 1912.

[24] Unfortunately many students of seed weight in its relation to viability or productiveness have not distinguished between small but perfectly developed seeds and those which are blighted or shriveled and immature. It is not at all unlikely that very different results will be secured from the two sorts.

[25] Weighings were made of each seed in units of .025 grams, that is, 0.000–0.025 grams = 1 unit, 0.025–0.050 = 2 units, etc.

[26] Since the seeds were taken quite at random any stringent selective mortality will be seen in the differences between the constants of the original bulk of seeds weighed and those of the sub-samples planted which actually developed to maturity. The method might not be adequate for a very low selective death rate. In any case it must be expected to give irregular results. A much more satisfactory method is to draw the comparisons between the constants of the seeds which died and the constants of those which developed. Appropriate data for field culture series are being collected. Large greenhouse cultures in sand in which the comparisons can be made between the seeds actually developing and those failing to develop fully substantiate the conclusions drawn from field tests.

differential mortality with respect to seed weight, I have combined in Diagrams 2–3 the data from the field trials already published with those from a series of experiments on germination in sand. The lumping of the two sets of experiments which differ in some slight but apparently significant details to give sufficient series to make smooth graphs is justified by the fact that individually they lead to essentially the same conclusions and that the data and minute comparisons are to be presented in full detail eventually.[27]

Diagram 2 shows the relative differences in type (mean seed weight)[28] between the total samples of seeds weighed and those which produced plants.[29]

Here the heavy vertical bar represents zero difference between the average weight of the total population of seeds and those which actually produce plants. The broken lines and circles to the right show on the scale at the bottom, where each unit represents one tenth per cent. the number and amount of the positive differences, that is to say of those in which the seeds which survived are heavier. The heavy lines and solid dots to the left of the zero bar indicate the number of experiments giving negative differences—*i. e.,* in which the mean weight of the series of seeds which produced plants was less than that of the general population—and the amount of the difference in relative weight.

Judging the areas of light and dark shading, by the eye alone, one would conclude that the surviving seeds are slightly heavier than the population from which they were drawn. But the deviation from the equality of division which would be expected if there were no relationship between the weight of the seed and its capacity for survival is only $4 \pm 2.98$ cases, and little significance can be attached to it. For the

[27] J. Arthur Harris, "Supplementary Studies of the Differential Mortality with Respect to Seed Weight in the Germination of Garden Beans." To be published shortly.

[28] Several varieties of beans grown under diverse cultural conditions are involved. The varieties with the largest seeds are about three times as heavy as the smallest. To express the differences in absolute weights has its advantages, but when the number of series involved is too large for individual labeling in the graph, it is best to reduce values to a relative (percentage) basis by multiplying the difference by 100 and dividing by the mean for the general population.

[29] Here lies one of the objections to combining the two series of experiments. In the field culture the eliminated seeds were those which failed to produce fertile plants. In the sand cultures the fate of a seed could be followed only to germination. Some of the seedlings were abnormal, but to avoid all possibility of criticism every seed which germinated at all was included in the viable class. Doubtless in field cultures some of these would have perished before producing seeds. By retaining all these we are possibly making out a poorer case for differential mortality than we might by considering a part of the abnormal seedlings incapable of survival to maturity under field conditions.

whole 78 series the mean difference is less than five tenths of one per cent.[30]

Thus if we confine our attention to the mean, there is apparently no selective elimination whatever, for within the limits of experimental error there is no certain change in the mean value of the character considered. But an entirely new and different light is thrown upon the whole question when the variabilities are examined. These are distinctly less on the average for the series which develop to maturity.

This is brought out with great clearness by Diagram 3.

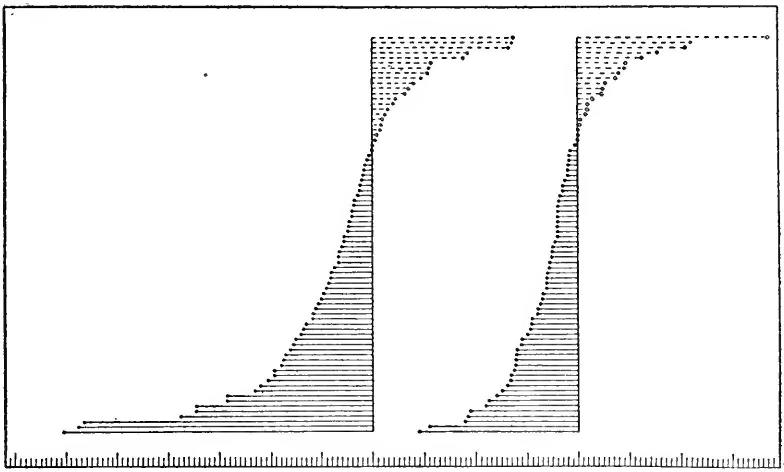


DIAGRAM 3. DIFFERENCES IN VARIABILITIES OF GENERAL POPULATION OF SEEDS AND OF THOSE WHICH PRODUCED PLANTS. The figure to the left shows the ratio of differences in standard deviation to their probable errors (1 space on scale = .2). The figure to the right shows differences in coefficients of variation (1 space on scale = .11 per cent.). The vertical lines give the points of zero difference.

In general form these figures are similar to the one representing the means, but an additional point is brought out by the one for the standard deviations, to the left. In this case the length of the bars indicates not absolute nor relative values of the variabilities, but the trustworthiness of the constants. Here the base scale is in terms of the ratio

$$\frac{\text{Difference}}{\text{Probable Error of Difference}},$$

each unit being equivalent to .20.

Instead of the light and dark line areas being approximately equal they are widely different. In only 22 cases is the variability of the

[30] The mean difference in weight is more nearly zero in the 28 field experiments than in the 50 made in the greenhouse. There may be valid biological reasons for this, but they can not be discussed here.

series of seeds which survive greater than that of the original distribution, while in 56 cases it is less. This is a deviation from equality of $17 \pm 2.98$, or over five times its probable error. One might have to toss coins a long time to get 22 heads and 56 tails in a series of 78 throws!

Furthermore, the individual constants indicating a lowering of variability by selection are statistically much more trustworthy than those suggesting a decrease. To carry much weight a difference between two constants should be at least two and one half times its probable error. But only 5 of the broken lines reach a straight edge laid 2.5 above (to the right of) the zero bar, while 22 extend beyond the same limit on the other side.

The coefficients of variation are already in relative terms—variability expressed in percentages of the mean—hence they may be represented directly by the direction and length of the lines in the figure to the right. For this graph, one unit on the base scale means one tenth of one per cent. The results amply confirm those secured by the preceding method.

These graphs are deduced from experiments involving tens of thousands of individually weighed seeds. Their evidence for a selective mortality can not, therefore, be lightly set aside. That the average weight remains unchanged while the variability is decreased can only mean that there is an elimination from both the upper and lower extremes of variation, that is, of both large and small seeds.[31]

Nevertheless, too great caution can not be used in the interpretation of the result. Purposely, the materials selected for study were most varied, and while the validity of the general *average* result can not be seriously questioned, there remains the problem of determining whether, and if so to what extent, the selective mortality may not fluctuate widely with different varieties and conditions.

The whole problem of the underlying physical and chemical causes of the differential mortality remains to be investigated. Finally, the possible relationship of the selective mortality to organic evolution can not be discussed until we have further evidences along several different lines.

*Potential Characteristics and Seed Mortality.*—When we turn to the question of the possible influence of the characteristics of the adult plant innate but invisible in the seed upon the chances of survival, the data are very scarce indeed.

Montgomery's studies of the rise in productiveness in corn as a result of increased competition may perhaps be of interest here. The

[31] Montgomery, *supra*, found little difference in the capacity of large and small seeds for producing mature plants in the cereals. Had he worked with the whole range in size and taken into account variability as well as type he might have found stronger evidence for selective mortality than he did.

most important case is undoubtedly that of single and double stocks. Double stocks are completely sterile, forming neither ovules nor pollen. They must, therefore, be propagated exclusively by seeds from singles. In the effort to place on the market seed which will produce the highest possible proportion of doubles, the closest attention has been given to all factors—shape and color of seed, position of the seed in the pod, position of the pod on the plant, etc.

At the beginning of the last century, the belief was current[32] that a larger proportion of doubles can be obtained from old than from recently harvested seed. Apparently, the original idea was that the transformation took place in the harvested seed, but Goebel suggested that its foundation may lie in a differential viability, the seeds which would have produced singles losing more and more their power of germination as time goes on.

Saunders[33] seems to have put the empirical conclusion and Goebel's interpretation on a scientific basis. In actual experiments which need not be detailed, she found that as the percentage of germination decreased by keeping the seeds for long periods of time, the proportion of doubles increased. She also found that when, through unfavorable conditions, the seeds were of a poor quality and a high percentage failed to germinate, the proportion of doubles was greater. Thus if the pods of 1909 be classified in two groups according to whether they produced less than fifty per cent. or fifty per cent. or more seedlings, we find for two strains:

| | Percentage Doubles in: | |
|---|---|---|
| Variety | Low Germination | High Germination |
| Marine blue | 72.0 | 51.5 |
| Light purple | 59.5 | 52.5 |

While Miss Saunder's results seem fairly conclusive the difficulties of the problem are, as she points out, considerable. A careful experimental investigation on a large scale of the viability of the seed in double stocks and in other ever-sporting varieties would be of the greatest interest.[34]

*Seedling Characters and Survival.*—Having shown that the measurable characteristics of the apparently normal seed, or the invisible potentialities of its embryo, may be of importance in determining its viability, *i. e.*, that they may be of "selective value," one next inquires whether in the young plantlet some variations tend to be weeded out.

We are indebted to Baur for a neat demonstration.[35] That plants

[32] See Goebel, Pringheim's *Jahrb. Wiss. Bot.*, 17: 285, 1886, for references.

[33] E. R. Saunders, "Further Studies on the Inheritance of Doubleness and Other Characters in Stocks," Appendix I., *Journ. Gen.*, 1: 361–367, 1911.

[34] Experimental work along the lines suggested by de Vries's discussion, "Species and Varieties," 2d ed., pp. 329–339, would be most important.

[35] E. Baur, "Untersuchungen über die Erblichkeitsverhältniss einer nur in Bastardform lebensfähigen Sippe von *Antirrhinum majus*," *Ber. Deutch. Bot.*

with inadequate photosynthetic apparatus would be incapable of survival seems on *a priori* grounds quite probable.[36] He found that in the snap dragon, *Antirrhinum majus,* a variegated or "aurea" form could not be bred true, but on self fertilization gave a progeny of "aurea" and green plants. The inbred green plants produced only green offspring, while the variegated individuals again gave two types of offspring in the ratio of two variegated to one green.

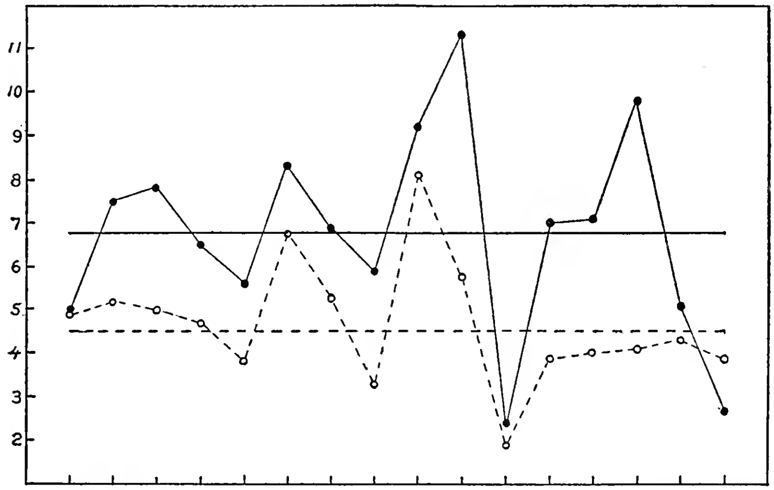



DIAGRAM 4. MORTALITY IN SIXTEEN LOTS OF TYPICAL AND ATYPICAL BEAN SEEDLINGS.

Evidence which need not be detailed here pointed to the conclusion that the variegated was the hybrid form, segregating on self-fertilization according to the simple Mendelian formula into one fourth green, one half variegated (heterozygous) and one fourth lacking chlorophyll —and consequently unfit for survival. Subsequent studies proved that the seeds incapable of forming chlorophyll are actually formed, but that they die in the early stages of germination, or before. Confirmatory results were obtained with a geranium, *Pelargonum zonale* "verona" where the seedlings lacking chlorophyll died at an early stage.

The preliminary results of a series of investigations on the struc-

*Ges.*, 25: 442–454, 1907. Also, "Die Aurea-Sippe von *Antirrhinum majus,*" *Zeitschr. f. Ind. Abst. u. Vererbungsl.*, 1: 124–125, 1909. Cf. also Bateson, "Mend. Princip. Her.," p. 253, 1909.

[36] De Vries ("The Mutation Theory," I., 229–230, 347–353, 1909; "Species and Varieties," 2d ed., pp. 537–538, 553) finds that *albida* mutants of *Œnothera* are very weak—exceedingly difficult to raise when appearing in the seed pan, and never found in nature.

Among large numbers of bean seedlings which I have grown in the greenhouse those with white, yellow or variegated primordial leaves have occasionally appeared. It has never been possible to grow these for any considerable time.

tural characteristics of seedlings in their relation to survival are at hand for garden beans, *Phaseolus vulgaris.*[37] From a lot of about 238,000 seedlings germinated in the greenhouse in sand, somewhat over 9,000 abnormal and normal plantlets were transferred to the field under as nearly as possible identical conditions. The diagram shows most clearly that the death rate, though very low, is unquestionably selective. Solid dots and lines represent the mortality of the atypical individuals in sixteen arbitrary but logical classes.[38] The actual numbers of deaths in these classes is not large. The death rates consequently fluctuate widely. Yet in every case but one the mortality of the atypical is higher than that of the typical individuals. The solid bar gives the rate for all atypical seedlings while the broken line smoothes the circles connected by broken lines in the same way.

Seedlings are thrown only into two classes, typical and atypical. The latter is highly heterogeneous, comprising a very wide range of structural variations. Possibly some of these are more fit for survival than are the normal individuals, while others are far less so. Only the collection of far wider series of data will settle the question. On an average the variations from type are clearly inferior. This is precisely the condition which one would expect if natural selection has been a factor of weight in the development of the structural characteristics of the seedling, for the most fit type would be the one preserved.

It is important to remember that this selective mortality is found in seedlings germinated under as favorable conditions of substratum and temperature as we could give them, and then transplanted to fairly good garden conditions. In nature, a considerable part of the seedling death rate doubtless occurs in the early stages of germination where the nascent root and shoot are subjected to a substratum far less favorable to growth than those of the seed pan. Again, the transplanted seedlings were practically free from the inter-specific and intra-specific competition which must be intense in nature. The detection of a conspicuous selective death rate under such optimum conditions can leave little doubt as to the force of natural selection under the severe conditions in which plants grow in nature.

*Pigmentation in Man in Relation to Selection.*[39]—The problem of

[37] J. Arthur Harris, "A Simple Demonstration of the Action of Natural Selection," *Science*, N. S., 36: 714–715, 1912.

[38] These comprise about ten "pure lines" each. The fact that the mortality of normals and abnormals tends to rise or fall together has no necessary significance for heredity. It is probably due, largely at least, to the fact that the two kinds of seedlings were under the same environmental conditions.

[39] So nearly all the work on pigmentation which falls in the scope of this paper has been done on man that a more general heading seems unnecessary. About the only other case for mammals is that suggested by the anomalous behavior of yellow in breeding experiments with mice. The problem has been

the relationship between the pigmentation of the hair and eyes of the individual and his mental characteristics, his bent towards criminality, his health and his capacity for survival has received the widest discussion.[40]

The relation of pigment to selection has been discussed chiefly from two points of view—that of urban selection[41] and that of susceptibility

As early as 1904 Pearson,[42] working with Pfitzner's data for Lower Elsass, suggested that the high correlation between age and pigmentation in the case of post mortem cases is more nearly explained by a selective death rate of the lighter types than by the assumption of a darkening with age alone. In the same year appeared a most suggestive paper by Strumball,[43] who attempted by the comparison of hospital censuses with the general English population to ascertain whether susceptibility to various diseases is dependent upon the anthropometric characteristics of the individuals affected. He concluded that blond features are associated with acute rheumatism, heart disease, tonsilitis and osteo-arthritis, and that the brunette traits are associated with nervous diseases, tuberculosis and malignant diseases.[44]

MacDonald[45] finds that for scarlet fever, diphtheria, measles and whooping cough among Glasgow school children recuperative power is

discussed by Cuénot, Little, Castle, Morgan, Bateson, Wilson, Durham and others. Apparently, no one has succeeded in finding a mouse pure to yellowness. The suggestion has been made that two gametes both having the determiner for yellow are incapable of uniting in fertilization or that they are not viable if they do unite.

[40] To mention even the chief of these papers, the most of which are based on data or methods inadequate for conclusive results, would require too much space.

[41] Anthropologists have devoted much attention to the highly complex problem of the difference in pigmentation between urban and the surrounding rural populations. Ripley in his "Races of Europe" gives a good general discussion.

to disease.

[42] K. Pearson, *Biometrika*, 3: 464–465.

[43] F. C. Strumball, "Physical Characters and Morbid Proclivities," Saint Bartholomew's Hospital Reports, 39: 63–126, 1904.

[44] Of course, general suggestions and some statistical work precede Strumball's work. To many of these he refers. More recently, in a discussion on "Heredity and Disease" (*Proc. Roy. Soc. Med.*, 2[1]: 96–98, 1908), he returns to some phases of the question and concludes that the onset of tuberculosis is earlier in blondes, but that the disease is more frequent in dark types.

[45] D. MacDonald, "Pigmentation of the Hair and Eyes of Children Suffering from Acute Fevers, its Effect on Susceptibility, Recuperative Power and Race Selection," *Biometrika*, 8: 13–39, 1911. Here he has brought together a detailed review of the earlier theories and evidences. While his résumé is restricted to writings by those of scientific standing, the diversity of results show that much of what has been authoritatively laid down is nothing more than casual observation and vague suggestion.

associated with hair color and eye color in such a way that the darker classes have the greater recuperative power.[46]

Pearson[47] has also demonstrated correlation of $r = .19$ between health and hair color and $r = .07$ between health and eye color for data relating to 2,317 boys. Similar results were obtained for girls.

But, on the other hand, there are contradictory evidences. For instance, the conclusion reached by Saunders[48] from his study of pigmentation and susceptibility to diseases in Birmingham school children is that pigmentation is not a factor in selection.

He also finds that relationships between pigmentation and stature and weight, if they exist, are of so delicate a nature that much more refined data than those furnished by the ordinary anthropometric surveys or school medical officer's reports are necessary for their detection.[49]

The discrepancy between his results and those of MacDonald is possibly due to differences in the nature of the populations dealt with. Perhaps, too, data derived from the official examination of school children are less reliable than the hospital returns.

Woodruff has attacked the problem of the relationship of pigmentation to selection from an entirely different, and most important, side.[50] He seeks to determine the relationship between skin color and survival in tropical sunlight. He concludes that the lack of pigmentation is

[46] These conclusions rest solely on the hospital observations. I omit those which involve questions concerning the liability to infection, since they require a knowledge of the distribution of pigmentation in the general population. Such comparisons involve the use of some such basis as the British Association standards or the general anthropometric surveys, which may not be valid for the particular district or social class from which the hospital or asylum inmates are drawn. This was true, for instance, in Strumball's pioneer study, which is highly suggestive rather than conclusive. Again, in attempting to settle the question of differential incidence by an analysis of hospital populations there is the danger of a large personal equation in the appraisal of non-measurable characters. Neither of these difficulties are met when studies of recuperative power are made by a single observer. See also K. Pearson, *Biometrika*, 8: 39, 1912.

[47] Unpublished results quoted by Saunders, *Biometrika*, 8: 355, 1912.

[48] A. M. C. Saunders, ''Pigmentation in Relation to Selection and to Anthropometric Characters,'' *Biometrika*, 8: 354–369, 1912.

[49] Miss Elderton, ''On the Relation of Stature and Weight to Pigmentation,'' *Biometrika*, 8: 340–353, 1912, concludes from her study of the relationship between hair and eye color and weight and stature: ''So far as the material goes we find that types of hair and eye color are not associated to any substantially significant extent with divergencies in height and weight in children between the ages of seven and fourteen, inclusive.'' It must be noted that Miss Elderton's problem was in large part undertaken to determine the influence of racial heterogeneity on stature, in its relation to environmental influence.

[50] Chas. E. Woodruff, ''The Effect of Tropical Light on White Men,'' 1905. Also, *Science*, N. S., 31: 620, 1910.

an immense barrier against the penetration of the blond races into the tropics.[51]

Summarizing in a word the results of these studies on man, we may say that the death rate is unquestionably selective. There are still those who assert that while natural selection applies to the lower organisms its force is *nil* in civilized society. Against such a view the evidence of biometric workers seems fairly conclusive. But concernng the way in which this selective death rate occurs we know lamentably little. Indeed, the whole problem of the basis of natural selection in man is open to investigation. The biometric work which has been done shows how complex the whole problem is, and how idle to attempt its solution by any means but the analysis of large masses of carefully collected data by refined statistical methods.

## III. Supplementary Tests of Fitness

The capacity of an individual for survival is doubtless dependent upon the fitness of its several organs for performing their respective functions, or upon the nicety of their coordination. At present, the ultimate goal of investigations of natural selection would seem to be the determination of the significance for survival of each deviation from type of as many organs or characteristics as practicable. Upon the evidences afforded by a comprehensive series of investigations of this kind must depend our final views concerning the significance of natural selection as a factor in organic evolution.

Fitness may be tested in various ways. A series of individuals may be actually subjected to a struggle for existence—be "exposed to risk," to use an actuarial term—and the difference between the series of individuals which survive and those which perish measured in terms of biometric constants. This is essentially the course followed in the studies reviewed in the preceding paragraphs. It is from the standpoint of the evolutionist the most direct method.

Fitness may, however, be tested in some favorable cases in which the individual lays down a series of organs (with measurable characteristics) only a portion of which may develop to maturity. Here one may find that the elimination of organs within the individual is not random, but selective. A comparison of the characteristics of the organs which fail with those which complete their development may furnish information as to the characteristics which make for fitness or unfitness for survival.

Again, physiological criteria—*e. g.*, efficiency in the maturing of

[51] One should also read the most interesting chapter on the problem of the white man in the tropics in Ripley's "Races of Europe." There, structural characteristics as well as pigmentation are considered.

ovules into seeds, or in the formation of well-developed seeds—may be found.

Obviously, it will be of great advantage if direct demonstrations of the action of natural selection can be supplemented (or in some cases it may be preceded) by evidences of an entirely different sort.

Such supplementary evidences have so far been sought only in the case of the organization of the plant ovary. Studies of the selective elimination of ovaries have been reviewed in the earlier paper on the measurement of natural selection.[52] Since then considerable side light has been thrown upon the problem of the intra-individual selective elimination of organs by two studies of a purely physiological character.

One of the characters dealt with in studies of the development of the ovary is the "odd" or "even" number of ovules which it produces. This is essentially a criterion of the bilateral asymmetry of the plate of carpellary tissue giving rise to a locule. In large series of pods of garden beans it has been shown[53] that pods with an "odd" number of ovules—that is, those which have the ovules unequally divided between the two carpellary margins, and are consequently bilaterally asymmetrical—are less capable of maturing their ovules into seeds than are those with an "even" number. Again,[54] all the available data indicate that the weight of the seeds is lower in pods with an "odd" than in those with an "even" number of ovules.

The interest of these results is heightened by the fact that the type of structure which in *Staphylea* shows an inferior capacity for development, in *Phaseolus* shows (by two different tests) a physiological inefficiency. As soon as proper materials and technique are available it will be of importance to consider asymmetry in its relation to the capacity for survival of the individual.

[52] The soundness of the conclusions of the papers there reviewed has been emphasized by a research which has appeared since that time ("Further Observations on the Selective Elimination of Organs in *Staphylea*," in *Zeitschr. f. Ind. Abst.- u. Vererbungsl.*, 5: 273–288, 1911). Here it is rendered highly probable that the observed selective mortality of ovaries can not be explained by such simple factors as a correlation between the position of the ovary on the inflorescence, with a heavier but purely random mortality in certain regions of the inflorescence. In another paper on methods ("On the Formation of Condensed Tables when the Number of Possible Combinations is Large," *Amer. Nat.*, 46: 477–486, 1912) evidence is brought forward for an interesting morphogenetic relationship between radial asymmetry of the compound ovary and its locular composition.

[53] J. Arthur Harris, "On the Relationship between Bilateral Asymmetry and Fertility and Fecundity," *Roux's Archiv. f. Entwichelungsmechanik*, 35: 500–522, 1912.

[54] J. Arthur Harris, "On the Relationship between the Bilateral Asymmetry of the Unilocular Fruit and the Weight of the Seed which it Produces," *Science*, N. S., 36: 414–415, 1912.

## IV. Concluding Remarks

A summary, properly so called, of the materials of this paper is precluded by the fact that the various sections are in themselves summary reviews of researches carried out upon the most diverse materials. But all these studies have this in common: they are attempts to determine by quantitative methods whether natural selection be a reality, and if so, to measure its intensity. In conclusion, stress may be laid upon two points.

The first of these is a matter of fact. Evidences of the occurrence of natural selection for many characteristics are rapidly accumulating. That mortality is not random, but differential, and that the intensity of the selective death rate is a problem open to quantitative treatment, are propositions supported by large bodies of sound scientific evidence. Nevertheless, neither the complexity of the phenomena nor the difficulties of the collection or of the analysis of the data can be underestimated. As yet, only the surface has been touched. The results are all subject to such revision as may be rendered necessary by wider data and narrower analyses.

The second of these is a question of interpretation. The demonstration of the existence of a selective death rate in a given case is by no means equivalent to proof that evolutionary change is taking place in the character under consideration. Natural selection may only maintain a characteristic at the stage already attained. Or the force of natural selection may be offset by that of some other factor. Or, again, the variations dealt with may be of a kind not inherited; and without inheritance selection is powerless to effect any change. Indeed, first-hand experience in quantitative work on organic evolution must convince any one that the problem of the methods by which it has taken place is far more recondite than biologists have been wont to consider it. This great complexity demands an attitude of extreme caution in generalization. For the present, we must be content to attempt to measure one possible factor after another in as wide a series of organisms as possible. Having done this, we may hope in time to form a fairly trustworthy conception of the resultant of these forces as they may be combined in nature.

## THE HIBERNATION OF CERTAIN ANIMALS

BY THE LATE WALTER L. HAHN, PH.D.

THE hibernation of animals is one of the most interesting phenomena of nature. The word "hibernation" comes from the Latin *hibernare,* meaning to go into winter quarters, but it has come to have a more restricted meaning, and we understand by it a protracted condition of lethargy, during which the vital activities of an animal are more or less completely suspended.

Some of the simplest or one-celled animals, the *infusoria,* have the ability to withstand extremes of cold and drouth for long periods by forming hard coverings or cysts about themselves and in this condition they may be completely dried up and blown about by the wind, reviving when favorable conditions return, perhaps months afterward.

This condition corresponds to the hibernation of higher animals about as closely as any of the other activities of these simple organisms correspond with the more complex life of the higher species.

As far as I have been able to learn, there is nothing corresponding to hibernation in those animals that are nearest the *infusoria* in the scale of life, the sponges, corals, jelly-fishes, starfishes and the hosts of other marine invertebrates. However, practically all insects in temperate climates (excepting some that live in the water) pass the winter in a dormant state. In some species the adult insect lives through the winter, in others only the eggs, the larvæ or the chrysalides survive. In some cases the insect burrows into the ground or seeks protection elsewhere; in others, the egg, larva, chrysalid or adult insect remains in the most exposed situations in temperatures at times many degrees below freezing point.

Without attempting to enumerate all the kinds of animals that hibernate or to discuss the general features of the phenomenon, I shall merely call attention to the well-known fact that frogs, toads, snakes, lizards and turtles, in temperate climates, seek protection during the winter months in crevices among rocks or buried in the soil or mud according to their especial habits. We will now pass on to a discussion of the hibernation of certain well-known species of the highest class of the animal kingdom, the mammals.

### THE BEARS

I mention the hibernation of the bears here, not because I have any new facts to contribute in regard to it or any personal observations to record, but because that while the general fact of their hibernation is well known, their hibernation presents many less well-known and peculiar features.

In the first place, bears are the largest animals known to hibernate, and the only members of the great order *Feræ*, or flesh eaters, that do so. However, all the species of bears do not hibernate. Some that inhabit tropical Asia are active at all seasons and, according to the testimony of many artic explorers, the polar bear is also.

Grizzly and black bears in the United States generally remain active until after snow has fallen and severe weather has begun, that is to say, until the end of November or later. There seems to be a great individual difference in this regard, however, and there are records of bears being seen in all months of the year. Whether those that are abroad in midwinter have been disturbed in their winter sleep or have never gone into winter quarters, I am unable to say.

In some parts of the country there was a belief among the pioneers that bruin swallowed a knot of wood before entering upon his long fast, the purpose being to nourish him or "to keep his stomach from shrinking."[4] How this absurd notion arose, I can not conjecture. The bears, like most other animals, become very fat in autumn when food is plentiful, and the fat is gradually resorbed by the blood and carried wherever it is needed in the body. The animal requires much less food while dormant than when active and there is nothing especially mysterious or unusual about its nutrition during this period. Neither is there any more reason why its stomach should "shrink" than that ours should shrink when we occasionally abstain from eating on account of sickness or any other reason.

The most remarkable fact in connection with the hibernation of the bears is the birth of the young during this period. With the black bear this occurs in January or February and the mother remains in her den for six weeks or two months longer. The young are generally two in number, sometimes one and sometimes three. It must be a tremendous drain upon the vital resources of the mother to nourish her offspring at the conclusion of this long fast and she would be wholly unable to stand it if it were not for the small size of the young which weigh only a few ounces at birth and find an ample resting place upon the palm of a man's hand.

### The Woodchuck

This animal is better known in some parts of the country as the "ground hog." Its appearance is familiar to most people, but it is not so generally known that this clumsy, short-legged, short-tailed inhabitant of underground burrows is a member of the squirrel family, as is the prairie dog of the western plains.

[1] I do not know how widespread this idea may have been, but I heard it as a boy in southern Indiana, 40 years or more after bears became extinct there.

Unlike the bear, the woodchuck is exclusively vegetarian in diet. A favorite food is red clover, but it also eats apples, berries, grass, growing grain, nuts, bark and tender twigs of trees and shrubs; and it seems to have a peculiar fondness for the green leaves and twigs of the sassafras. During the spring and early summer these animals wander about, when their family duties permit, and consume great quantities of food. By September they have become very fat, and instead of going out two or three times a day to feed, they probably do not go out more than once, and when the days become chill, not that often. The time at which they begin to hibernate doubtless varies with the locality and the individual animal. In southern Indiana, where most of my own observations have been made, they retire about the end of October, or when the acorns and beech nuts are falling and the forest's red and gold is giving way to brown.

As to the condition of the animal during its long period of torpor, I know nothing. It is said to retire to a lateral chamber in its burrow, where it shuts out the cold air by filling the entrance with earth. There it remains for about five months, eating nothing, probably very cold and with its circulation and respiration reduced to a minimum.

In many parts of the country there exists a curious superstition (I know no better name for it) that "the ground hog" comes out from his winter's sleep on February second, and if the sun shines forth so that he can see his shadow he will retire to his hole and stay there six weeks longer, and there will be six weeks more of winter weather. There is doubtless some connection between this date and Candlemas day, for there is a stanza of an old poem, the origin of which I do not know, that begins:

> If Candlemas be fair and bright
> Then winter will take another flight.

How the "ground hog" came to be connected with Candlemas remains a mystery. The late Professor Otis T. Mason, of the Smithsonian Institution, an authority on American folk lore, told me a few years ago that he had no idea where the "ground-hog day" fable originated, and he also stated that it is, or was, unknown south of Mason and Dixon's line.

There has been a dispute in some quarters as to whether "ground-hog day" is really the second day of February or the third. To settle the matter, a bill was introduced into the legislature of a certain state a quarter of a century ago to appropriate two thousand dollars to defray the expenses of a scientific commission that should investigate the matter and settle the dispute for all time. The bill did not become a law. Perhaps it is on this account that the perverse "ground hog" refuses to come out on either of these dates. The exact time of awakening from his prolonged sleep probably depends somewhat upon the temperature, but this remains to be proved. The earliest that I have known ground hogs to come out was the third week in February in the extremely warm season of 1907 in the region already referred to—southern Indiana. They seemed all to emerge at about the same time, for I saw a number of places where earth was thrown out of their holes and their tracks were left in the soft clay, although it was two weeks later before I saw any of the animals, for they are extremely wary and active at this season. When they first break their long fast they are very thin and eat twigs, grass or almost any tender herbage that can be found. Perhaps it is on this account that they pay no attention to cold when once out. In the year in question we had cold weather and several inches of snow about two weeks after I noted the first signs of woodchucks; but it failed to keep them in. Mating time is then at hand and this, no doubt, is an additional incentive for them to remain active.

### Bats

Bats are more numerous in tropical and subtropical countries than in cooler climates. They do not hibernate there, although the presence of large numbers of some of the species in certain caves suggests that they may remain there for days at a time without going out to feed.

Bats are capable of flying very rapidly for a considerable length of time and it is not surprising that some species living in temperate climates migrate southward in winter. As far as we know, this habit is limited to three or four species in northern North America. These have their summer homes in trees throughout the wooded region from the Ohio River to Hudson Bay and migrate southward to spend the winter in the Gulf States. Whether they also hibernate for a time, I am unable to say.

The most conclusive evidence of their migration is the fact that they have never been found in the northern limits of their range in winter, and seldom or never in the southern limits in summer. In a few instances their southward flight in early autumn has been observed. The northern range of these migrating species is occupied by six or eight other kinds of bats that are not known to migrate regularly. These hibernate, chiefly in underground caverns, but sometimes perhaps in attics, deserted buildings and stone walls.

I have studied the hibernation of these animals in the limestone caves of southern Indiana. Other species have been studied in Europe, but what I shall say here is based almost entirely on my own observations.

A bat in normal sleep rests with head down, suspended by the pointed and curved claws which are hooked about some small protuberance, such as a rough place on the bark of a tree or a rough stone; the wings are folded along the sides. Sometimes the body rests against a vertical surface and a pair of claws (they are really the animal's thumb nails) on the wings help to support the weight. More often the animal hooks its claws to the rough stone ceiling of a cavern and does not touch a solid support with any other part of its body. The body sways gently back and forth as the animal breathes, and its breathing is rapid. It is easily awakened by a touch, a noise or even by bringing the heat of a candle near it. The parts that are not covered by hair feel warm to the touch.

The hibernating animal is found in the same locations and the same attitude as the sleeping animal. It does not sway with a regular rhythm, and if you give it a mere cursory examination you may be convinced that it is not breathing. However, a longer observation will show that at irregular intervals, perhaps minutes apart, it will respire in a convulsive manner for a few times and then become quiet. It is not easily disturbed by a noise or by warmth. If you rudely snatch it from its place and then release it, the animal is absolutely helpless and falls to the ground with wings still folded. The hairless parts of its body are cold to the touch.

However, a severe disturbance will arouse it, no matter how soundly it sleeps or at what season it may be. It then begins to breathe, not rapidly nor regularly at first, but with so much violence that it seems as though the whole body will be torn to pieces. The wings and legs move spasmodically and the temperature rises rapidly. In a few minutes the bat is wide awake and active. Between the two extremes of light sleep and deep torpor, every gradation exists.

Between April and August bats rarely enter the caves. During this period they rear their young, spending the days in trees and out-of-the-way nooks and crannies, and the nights in chase of insect food. Some time during August they begin to return to the caves in considerable numbers, and during this month I have found many of the animals as torpid as at any time during the year. In every instance the torpid animals were exceedingly fat. This should not be understood as implying that these creatures remained in this condition without taking food until April. Indeed I am very certain that this was not the case, but the reasons for so thinking will be developed later.

By the first of October it is probable that all of the bats have deserted their colder outdoor retreats and have come into the caves, but even now all do not remain continuously, but some go out to search for food when the nights are not too cold. I have not seen them out later in the season than the middle of November, but it is not improbable that some may venture out at any time during the winter if balmy nights occur.

During the late autumn the greater number are found in the large interior chambers of the caverns, half a mile or more from daylight, and not, as a rule, in dense clusters, although thousands may be hanging on a few square yards of rock. The positions of a number of bats were marked on the roof of a low chamber early in October. A week later about one third had moved, two weeks later half had moved and at the end of a month not one remained in its original position. By the end of December this chamber was entirely deserted and its occupants were scattered and were, for the most part, in higher chambers, where they were difficult of access.

The first week in January was very warm, and at this time I found many of the animals clustered near the cavern entrance. There is little doubt that some of them went outside, but they are unfitted for securing food that is concealed and they probably found few, if any, insects on the wing after nightfall. A sudden drop in temperature a week later was accompanied by a rush of cold air into the caves, and this scattered the bats and sent them into the inner recesses where the temperature is very nearly constant the year round. During February they again began to congregate near the entrance and the numbers increased and diminished irregularly until late in April, when they rapidly diminished as the bats left the cave for the season.

This, in brief, is the winter life of the cave bats. It begins, with some individuals, in August but is interrupted before winter begins. During the winter they move about to some extent and become more restless at the approach of spring, but are not able to get any considerable quantity of food until warm weather begins in earnest, usually in April.

The torpid condition of hibernation is induced by abundance of food and is not dependent on cold weather. The animals can be awakened from their lethargy at any time by mechanical disturbance alone. They are also made active by hunger after most of their fat is absorbed, but the end of their fast is determined directly by food supply and indirectly by weather conditions.

### The Thirteen-lined Ground-squirrel

This animal is an inhabitant of the upper Mississippi Valley from Indiana to the Rocky Mountains. It is better known as the "striped gopher" but the gophers are very distinct, zoologically, while this species, as its name implies, is a squirrel.

It is closely related to the familiar chipmunk of the east, which it resembles in size and habits, although it is more slender of build and differently colored. In the region where it abounds it lives on the lawns, in the orchards and pastures, along railway embankments, and, in fact, almost everywhere. Hence it is easier to study than the chipmunk, and this is the reason for selecting it in preference to the more familiar eastern animal.

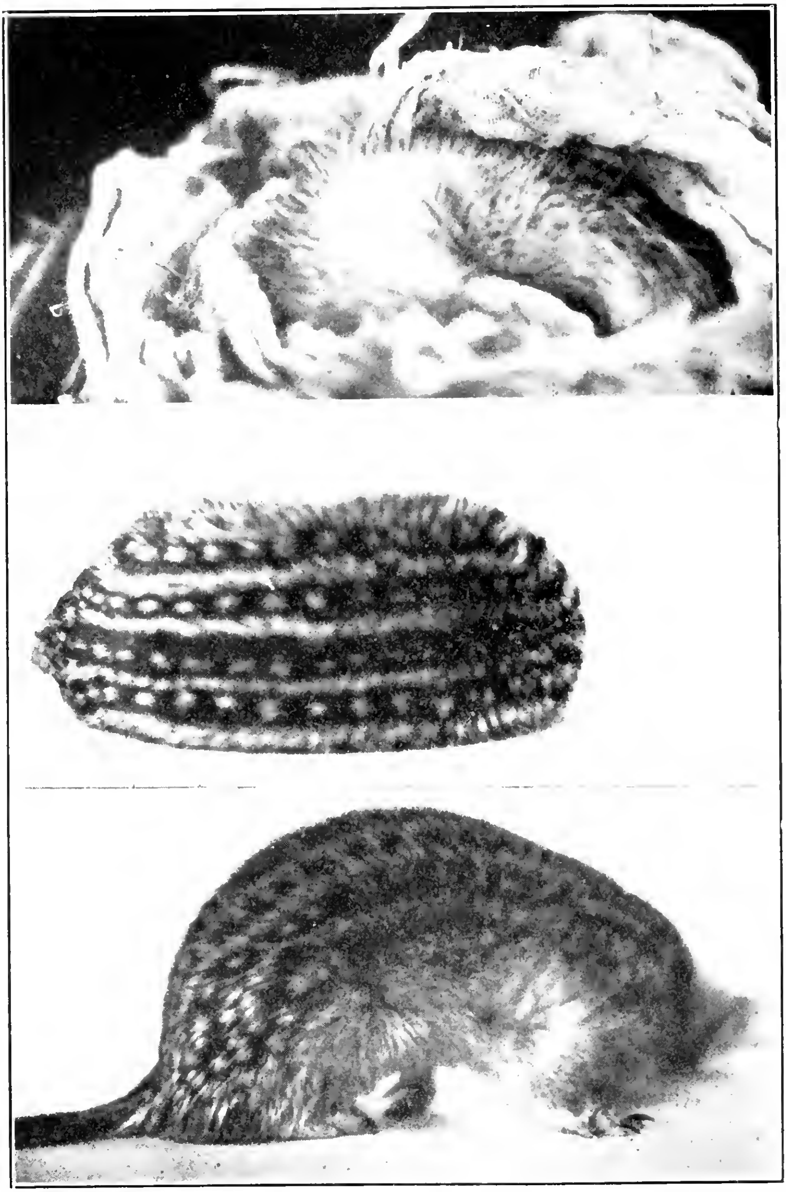
The food of this ground-squirrel consists of a few grasshoppers, crickets and beetles, some grass blades and other tender leaves and growing tips, a few roots and a very large proportion of grains and other hard seeds. Soft fruits, apples and berries are not despised, but seeds must be regarded as the staple diet of the animal.

The home is an underground chamber, reached by a hole going down almost vertically for about a foot and then turning horizontally and ramifying into two or more passages. Generally there are two or more vertical passages connecting the burrows with the outer world. The young are born in these subterranean homes some time during the early summer. The family breaks up in the late summer and apparently the young make new burrows for themselves and the animals hibernate singly, but of this I am not sure.

Hibernation begins at the onset of cold weather. The exact date of their final retirement to winter quarters varies with the season, the locality and the individual, and yet there is a certain amount of uniformity about it. Thus in 1909 in southern South Dakota there was no frost until October 9 or 10, when the temperature suddenly dropped and on October 11 it was several degrees below freezing point with a bitter northerly wind that made it seem much colder. Until this "cold snap" I had seen ground-squirrels daily. Afterward, there was a period of three or four weeks of very balmy weather, but I did not see another ground-squirrel although I had excellent opportunities had they been active.

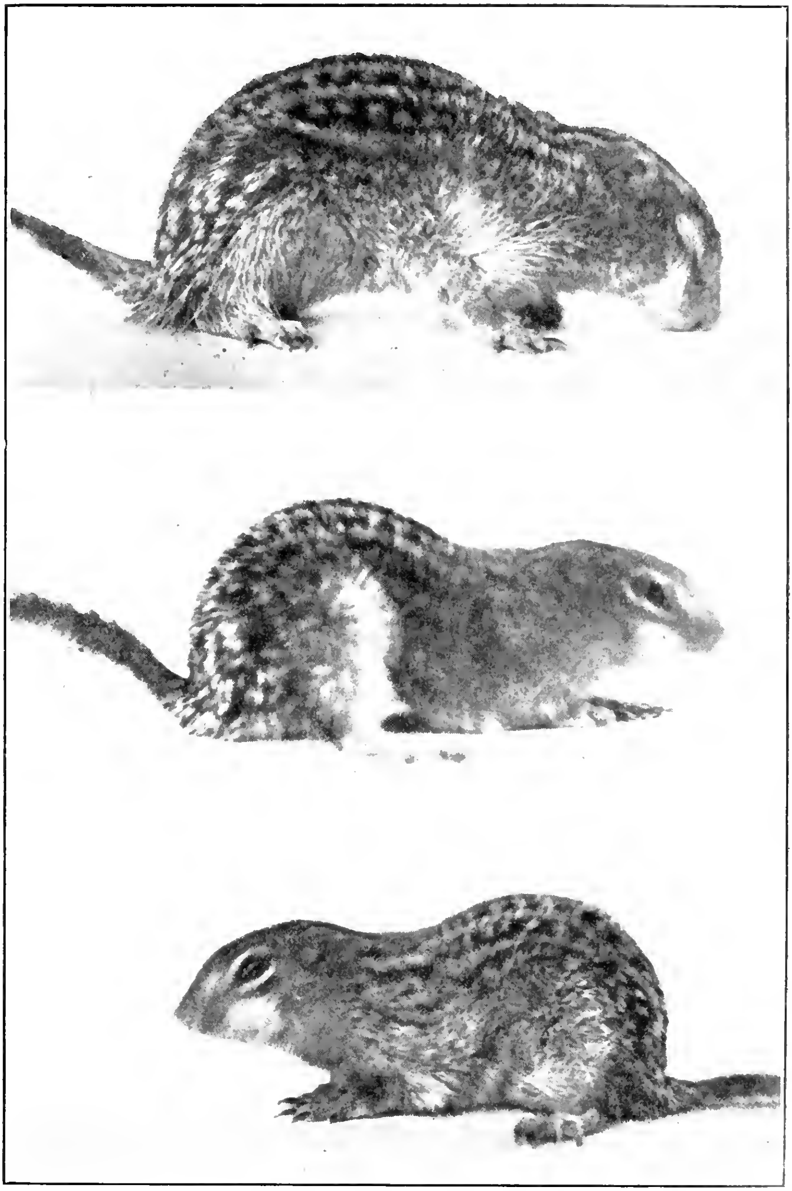
The end of their hibernating period varies somewhat and it probably depends somewhat upon the temperature. On the banks of the Missouri River, in South Dakota, the first of these little animals are usually seen whisking about their burrows some time late in March. Usually a number are to be seen on the same day that the first one appears. In this they show a striking similarity to the woodchuck as they also do in their habit of staying out in all kinds of weather, once they have made the venture. Thus in the spring of 1910 in mid-April we had a snowstorm lasting two days and piling the snow up three feet deep in places. The very day that the storm subsided I saw ground-squirrels running cheerfully about, buried to their hips in snow.

A captive animal of this species afforded opportunity for a very interesting winter study. He was captured in an insect net in September and placed in a wooden box which had a front of fine wire mesh. He was fed corn, small grains, potato, apple and sweet potato. Water was given him also but he did not seem to use any of it and I finally ceased to give it. The small grains were the favorite food and he would not eat the outer part of the corn grain unless driven by actual hunger although the heart (embryo) of the grain was gnawed out. The cage was kept in the supply closet of my laboratory. The former was without



AWAKENING FROM HIBERNATION

Thirteen-lined ground squirrels dormant in nest.
Removed from nest, but still dormant.
Waking; head moved convulsively.



OF THE THIRTEEN-LINED GROUND SQUIRREL.

Becoming more steady.
Nearly awake; head and tail still quivering.
Wide awake and active.

a window or heating device, but the door into the laboratory was open a part of every day. While the closet was dark the animal slept; when lighted, it was active for several hours a day, but always went to sleep when the early shadows began to fill the room. On the back of the cage there was a small door which was fastened by a pivot and opened by lifting one corner. It was not long until the little creature learned to open the door and forage for himself. His curiosity was insatiable and he climbed all over every part of the laboratory and carried back to his cage everything he could find in the way of food, as well as a quantity of rags kept for cleaning laboratory apparatus, but which he used to make a nest for himself.

His quarters were, of course, warmer than those of his brothers out of doors and I at first thought that he would not hibernate, but the heat was allowed to go down over Saturday and Sunday and in December when the temperature fell below zero outside, the room temperature reached freezing point or lower. The first time this happened, I missed the customary recklessness of my little pet on Monday and at first thought that he had escaped or was dead. But a closer examination showed that he was asleep inside the mass of cotton, rags and paper that composed his nest and with a heap of half-eaten kernels of corn by his nose. His body felt cold, and lay inert in my hand when I unwrapped him and I put him back again after covering him up as he was before, but did not fasten the door he had learned to open. The next morning I gave him no attention and it is difficult to say which was discomfited the most, myself or the class, when he scuttled across the laboratory floor and under a table where four girls were working, paused to sniff at some seeds that had been dropped by a class in botany and then darted to a well-known place of concealment behind a large stationary cupboard.

He did not take another prolonged sleep until I left for the Christmas holidays. During vacation the fire was again allowed to go down until there was just sufficient to keep steam pipes from freezing, and I was not surprised to find him dormant at my return. This time I determined to allow him to continue his winter's rest, so I kept the only door of the closet shut and the temperature remained fairly constant at a few degrees above freezing, perhaps falling to freezing point on Saturday and Sunday, for the walls separating the closet from the adjoining rooms were thin and the temperature within them changed slowly. Under these conditions, the sleep was prolonged somewhat more than a month and its termination coincided with a period of warmer weather. However, that did not end the hibernation of the animal, for several times afterward he slumbered soundly for a few days at a time. Each time he awoke he ate heartily and was quite active. When asleep it was possible to awaken him by taking him up into the hands and stroking him or handling him roughly.

At such times the first visible indication of awakening was a more rapid and convulsive breathing. This was followed by slow and feeble movements like those of a helpless young animal. Finally he opened his eyes, then took a few steps and soon fully regained his powers of motion.

This awakening is well illustrated by the accompanying photographs, which are presented, not as good examples of the photographer's art, but as poor photographs representing a subject which I believe has never before been illustrated. I have not been able to duplicate the series, which was taken under difficulties, as the day was dark for indoor photography and I had to work in a cold room. In addition to this, I had no idea of getting anything more than a single picture of the sleeping animal when I began and hence was unprepared to take a series and had to work rapidly. The series covers a period of about twenty-five minutes.

# SOME ABNORMALITIES IN APPLE VARIATION

By W. J. YOUNG

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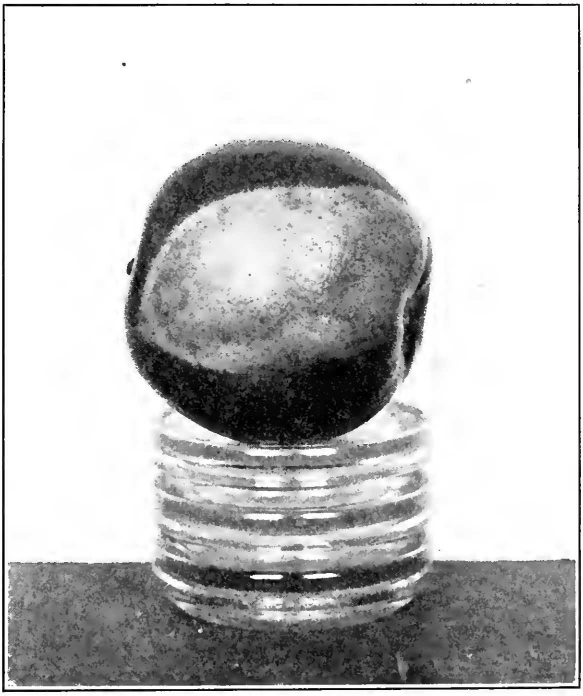
IF one were to enumerate the chief characteristics of the apple, its variability would doubtless come well toward the head of the list. A species which has been so long under domestication, which has been removed to so many localities where it is not native and subjected to conditions so different from those of its original habitat and which has such a complex ancestry as our modern apple, may well be expected to display a great variety of forms, and among the number some of such abnormal character and infrequent occurrence as to be reckoned as curiosities. It is not my intention in this article to discuss the variation of the apple in general, but only to jot down some notes concerning a few such freaks as have come to my attention during the past season.

First of all, I wish to consider some curiosities of apple coloration. It is pretty generally understood that, other conditions remaining the same, the color of an apple depends to a great extent upon the amount of sunlight to which the fruit has been exposed. The apples grown on the shady side of the tree are apt to be somewhat poorly colored, and the shady side of an apple itself is nearly always less highly colored than the side exposed to the direct rays of the sun. Every one is familiar with the nicely contrasting light spots which are common on our dark red apples where they have been shaded by some friendly leaf, and such spots, if not too extensive, are usually regarded as adding to the attractiveness of the fruit. This effect of sunlight and shadow upon the color of an apple is so well understood that it is often made use of in printing various designs upon the surface of the fruit. It is not often, however, that an effect of this kind is produced wholly without intention, yet that such a thing may happen is shown in the illustration. This specimen of nature's color photography represents a leaf with petiole, midrib and marginal teeth. The apple is of the McIntosh variety and is one of a number which resulted from artificial cross pollination. In order to prevent the loss of the apples in case they should drop from the tree before picking time, they were enclosed early in the season in small sacks of mosquito netting. This particular specimen happened to so press against the interior of the sack that a leaf was held firmly against its side, and the nearly perfect print of the leaf was the result. The faint lines which appear in the dark portion of the surface are the prints of the threads forming the sack.

Though the effect of the sunlight upon the color of apples is so well known, the nature of the pigment formed and the changes which it may undergo are not well understood. It is apparent from chemical studies that iron is present in its composition and this has led to the belief in some quarters that a soil rich in iron compounds is a factor of prime importance for the production of highly colored fruit. As a matter of fact, iron is also necessary to the production of chlorophyll in the leaves,

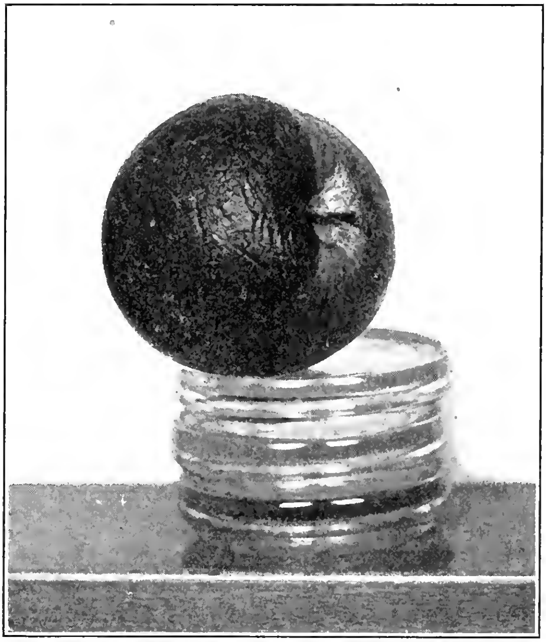


PRINT OF A LEAF UPON THE SURFACE OF AN APPLE ABOUT ONE HALF NATURAL SIZE.

and since the ash of the leaves contains a larger proportion of iron than that of the fruit, it seems fair to suppose that soils containing sufficient iron for proper chlorophyll development also have an abundance for the formation of pigment in the fruit.

Even more obscure are the causes which lead to the formation of pigment in certain varieties while it is absent or nearly so in others. While the color is no doubt greatly influenced by heredity, this fact takes us but a short step nearer the solution of the problem. It was formerly held that not only the color but also the form, size and flavor of an apple might be greatly influenced by the variety furnishing the pollen with which the blossom is fertilized. This theory is generally discredited at the present time, as well authenticated instances of such direct effect of the pollen are lacking in the case of the apple. The direct effect of pollen upon the color of the fruit is the rule in corn, as is well known, and it is not impossible that it might sometimes be manifest in the apple, though proof of that fact is lacking. At any rate, specimens are sometimes found which strongly suggest the direct influence of the pollen, and it has been my fortune to examine a half dozen such apples last season.

The first to come to my attention was grown in the Lake Chelan locality and appeared to be a small specimen of the Ben Davis type.



PARTICOLORED APPLE USUALLY ASCRIBED TO BUD VARIATION BUT SOMETIMES REGARDED AS SHOWING THE DIRECT EFFECT OF POLLEN. About one half natural size.

It had been picked for some time when received and was badly shriveled. The larger part of the surface of the apple was greenish indistinctly striped with red. A segment, however, covering about two fifths of the surface was of a very dark color with scarcely a suggestion of striping. The lines of demarcation between these dissimilar portions of the surface were clearly and sharply marked, as shown in the illustration, and extended from stem to calyx. Upon cutting the apple, it was found that the dark portion of the surface just covered two of the carpels or divisions of the core. This portion contained three perfect seeds, while there were five seeds in the remainder of the core.

The second specimen of this kind was a McIntosh apple from the experiment station orchard. In this case the larger portion of the surface was of the normal red color of the variety, but a segment of about one third of the surface was very light in color, faintly streaked with pink. The two sections of the surface were clearly marked off from each other, though the lines of demarcation were not quite so sharp and regular as in the specimen already described. The light-colored segment covered approximately two carpels of the core, although the open nature of the McIntosh core made it more difficult to determine that point accurately in this apple than in the other. Each part of the core contained four seeds. Two of these were abnormal and will be described farther on in this paper.

A poorly colored apple of the Arkansas variety received from White Salmon had a brownish red band extending from stem to calyx, covering a fifth of the surface. On the opposite side of the apple was a similar streak, but only about an eighth of an inch wide. The dark portion included one carpel containing a single seed, while the remainder of the fruit contained but one good seed. A Winesap from the Yakima Valley had on the lighter-colored side a deep red stripe covering about an eighth of the surface and including one carpel. This portion of the core contained one seed while there were seven seeds in the remainder of the fruit. A Rome grown at Pullman had half of the surface of a nearly solid red color, the remainder being green with red splashes. The lighter portion contained three seeds and the dark part two. A second specimen of Rome from Pullman had a dark area covering two carpels, an area of moderately light color, also covering two carpels, and a still lighter portion covering one carpel which was seedless. The other portions contained three seeds each. The seeds from the differently colored portions of all these apples were saved separately and planted in the hope of obtaining some light in regard to the significance of such abnormalities.

Turning from freaks of color, we will next consider some apples of abnormal structure. The doubling of fruits or the multiplication of parts is a variation of less common occurrence in the apple than in some other species. Certain varieties of the plum, for example, ordinarily produce a fairly large proportion of double fruits. These result from the presence of two complete pistils in a single blossom. Analogous cases of polycarpy occur in the apple, though less frequently than in the stone fruits. Apples having six carpels have come under my notice in the Grimes, Rome, Gano, Delicious, Chelan and Yellow Newtown varieties, and I have observed blossoms of the Golden Sweet having six pistils. The Yellow Newtown seems especially prone to this kind of variation and a number of specimens were found the past season containing six carpels, and in one instance a fruit with seven carpels was noted. The

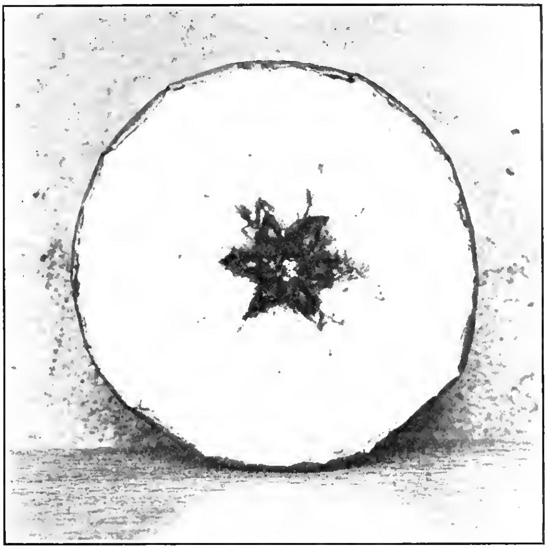
POLYCARPY IN THE APPLE. Yellow Newtown apple, having seven carpels. Natural size.

latter specimen had six calyx lobes, though the multiplication of carpels seems to take place as a rule independently of the other floral organs. An extra sepal, or possibly a bract, below the calyx and on the side of the tube, is not so very uncommon on fruits otherwise normal in structure and persists in the fruit as a scale on the side of the apple, usually deforming it somewhat.

I have never observed the suppression of carpels in apples of the ordinary varieties, though it may occur in some of the so-called seedless or coreless forms. In case one or more of the pistils fail to receive pollen while the remainder are successfully pollinated, the corresponding carpels appear always to develop more or less with the growth of the fruit, though they remain empty.[1]

Double apples, though comparatively rare, have occasionally been described and two such fruits were found at Pullman last season, one in the orchard of the experiment station, the other in an orchard adjoining the college campus, while a third was received from Wenatchee.

[1] Since these notes were written a student has discovered specimens of the Rome and Gano varieties having four carpels and very rarely three carpels; also seven carpels in the latter variety.

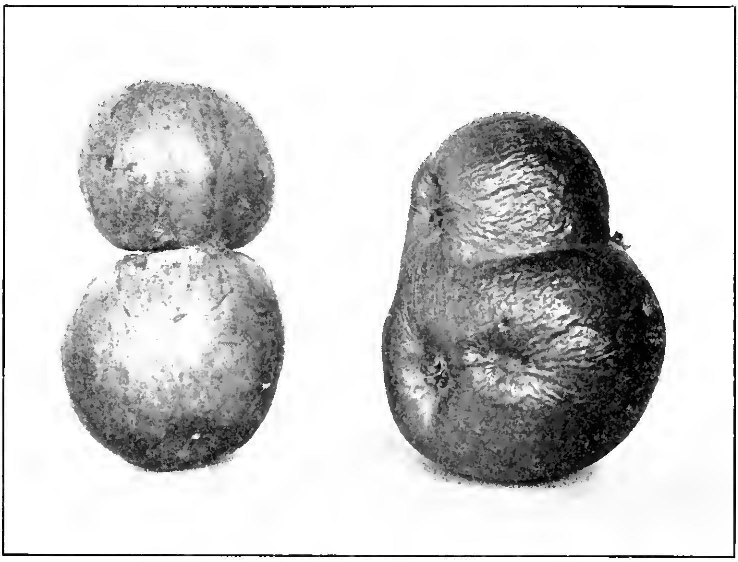


POLYCARPY IN THE APPLE. Grimes' apple having six carpels. Slightly reduced.

The first, a specimen of the Ben Davis, consisted of two nearly independent apples united for only a short distance near the base. The stem, originally single, had been split nearly to the base, while that part of the fruit between the insertion of the stem and the point of union of the apples had been broken apart as the apples had developed at the base. The two portions, thus almost completely separated, had each developed into a nearly perfect apple, though of small size. The cores were perfect and the axes, which were nearly straight, extended in almost opposite directions.

The second specimen, a Jonathan, consisted of two apples of unequal size joined together throughout their entire length and marked off from each other only by a shallow groove. The single stem upon which the fruit was borne was split for a short distance as the two portions spread apart in growing. When cut open each section was found to have an independent core containing perfect seeds, although in the smaller part that portion of the core adjacent to the other part was undeveloped. The axes of the cores, moreover, were strongly curved away from each other. The specimen from Wenatchee was similar in all important respects to the one just described and further account of it will not be necessary. Both of the double apples grown at Pullman are shown whole and in section in the accompanying illustrations.

Double apples of this kind originate in a manner quite different from the double plums mentioned above. The presence on the mature apple of two separate calyx cups indicates that these apples were produced by distinct blossoms borne at the end of a single flower stalk. In

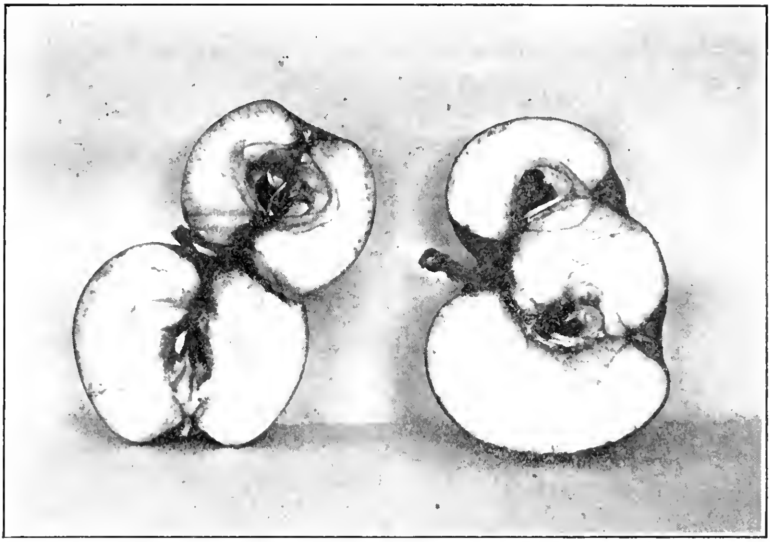


DOUBLE APPLES. About two thirds natural size.

the apples last described the receptacles of the blossoms must have been united nearly to the base of the sepals. In the first specimen, however, union appears to have taken place only at the base.

Polyembryony, or the multiplication of the embryos in the seed, is a condition normal in certain cases, notably in the citrus fruits and the Mango. Such seeds arise from ovules containing a single egg cell which gives rise to one of the embryos; the others originate as outgrowths, by a sort of budding process, from the inner wall of the embryo sack and of course reproduce the parent form as perfectly as other methods of bud propagation. True polyembryony must not be confused with the presence of more than one seed in an indehiscent fruit which normally contains a single seed. Such an occurrence is quite common in the peach and related fruits where the stone is really the endocarp or inner portion of the fruit and may enclose two seeds produced independently of each other, though the normal number is but one.

The carpels of the apple may contain from one to four seeds each, though the most common number appears to be two. I am not aware that a polyembryonic apple seed has been reported up to this time; however, one of the seeds in the abnormally colored McIntosh apple already described contained two embryos, while a second seed of the same character was found in another specimen of this variety. The manner of origin of these accessory embryos was not determined, though each embryo appeared to be surrounded by an independent inner seed coat. This fact would seem to indicate a method of production different from



DOUBLE APPLES. Section about two thirds natural size.

that of the polyembryonic seeds already noted, perhaps by a sort of fasciation or doubling of the ovule and the production in it of two distinct egg cells.

The seeds of the McIntosh apple appear, indeed, to abound in anomalous forms. Another seed in the same abnormally colored apple was remarkable for its small size, being perfectly formed, but of scarcely one fourth the length of an ordinary seed. Other seeds of this variety have been found in which the seed coat failed to develop and the embryo grew to full size without the usual brown covering, traces of which were found as a small patch at the hilum. An instance of this kind has also been noted in a seed of the Rhode Island Greening. In other cases the seed coats have split open as the seed developed, apparently as the result of the excessive production of endosperm which protruded as an irregular whitish mass containing the embryo. Though it is possible that such forms are the result of some unnatural state of nutrition in the seeds of this variety, nothing is known of the conditions which give rise to their production. Owing to the comparatively infrequent occurrence of abnormal forms, an investigation of their underlying causes is more difficult than the study of normal variation and progress is consequently slower.

# SCIENCE AND POETRY

By Dr. CHARLES W. SUPER
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IN the year 1910 there were published in the United States, in round numbers, 13,500 books. This was an increase of about 2,500 over the preceding year. The total for Great Britain was nearly 21,000 for the same biennium. The German output was over 31,000 volumes, the variation between the two years being small. But compared with 1900 these figures represent an increase of nearly 6,000 volumes. The total number of book publications now reaches about 150,000 volumes annually, although in some countries pamphlets are also reckoned as books. In 1910 there were issued in the United States and Great Britain nearly 5,000 volumes under the head of fiction, poetry and the drama, the latter country slightly exceeding the former. To these should be added many translations, cheap reprints of novels of a more or less standard character, and a large number of plays, mostly comedies that are performed in every village, town and city from one end of the land to the other. Besides, a great quantity of both prose and verse never appears in book form. One can hardly take up a popular periodical without finding in it some of each, while many contain little else. Furthermore, a great many articles and even books are so permeated and even vitiated by the personality of the author when professedly dealing with facts that they may properly be relegated to the domain of fancy. Their contents pass through the mind of the reader, leaving hardly more residuum than the smoke that goes up a chimney. We need also to remember that the enormous output of the religious press is largely occupied with questions of a more or less theological character as distinguished from practical christianity, and is so colored with the views of the writers that it may be classed under the head of imaginative literature. We may make the same statement of almost all history dealing with periods more remote than two or three centuries. Hardly any two writers agree as to the reliance that should be placed on the so-called original documents; and there is no way of deciding the points at issue. Even subjects of a strictly scientific character appear to need the touch of the magic wand of the writer endowed with a vivid imagination to make them popular. In this kind of literature the French occupy the foremost place. Such books as Macé's "History of a Mouthful of Bread," Verne's fantastic stories, Figuier's "World before the Deluge," and others, have been translated into almost all modern languages and sold in great numbers. When we take into account this enormous mass of printed matter, to which should be added the newspapers; and consider further that many of the metropolitan dailies contain enough words to make three hundred large volumes every year, we are constrained to believe that the present generation is one of readers, not of thinkers. We are in fact told now and then that thinking has almost become a lost art. In science a concept is recognized as produced by an external entity, or at least by an entity external to the cognitive faculty, as when it takes cognizance of its own operations and states. These concepts are verifiable by any number of experiments and observations and must agree in the main. Science deals with things that can be counted, or weighed, or measured. In poetry, speaking by and large, concepts are also recognized as external entities, it is true, but there is no agreement between any two observers and the phenomena are not verifiable. In truth, in all primitive poetry phenomena are envisaged as external, because the mind, though aware of its own operations, is unconscious of them. An important element of poetry is mythology, and mythologies are not the exclusive possession of primitive peoples. In the Homeric poems all mental states are regarded as external objects. We find the same conditions in the Old Testament. God is represented as speaking to men out of a corporeal body, or in dreams. This is just what we find in early Greek poetry. We can not draw a clear line of demarcation between the figments of the imagination and facts any more than we can do so between light and darkness. The imagination frequently leads to wholly diverse interpretations of the same data, as may often be seen in history. Here science finds its most difficult field of operations. What is called the historic imagination differs widely in different writers. Variety or lack of uniformity is a prime characteristic of all poetry. No productions on the same theme are exactly alike. In science there is a substantial agreement among any number of persons. The same feeling or emotion finds expression in many different ways. What an endless variety of treatment there is of the familiar theme of romantic love! It may be, however, that the passion does not manifest itself in exactly the same way in any two persons. This may seem a strong statement, but it is neither extravagant nor exaggerated in view of the circumstance that of all the millions of human beings upon the earth no two are so much alike that it is impossible to distinguish one from the other. The imagination often casts a glamor over persons of the opposite sex and endows them with attributes which they by no means possess. This state of mind is amusingly exhibited by Don Quixote with his rhapsodies over Dulcinea del Toboso, although she was in fact nothing more than a plain and coarse village wench. Similar instances occur not only in fiction, but even in greater abundance in real life. Here lies the limitless domain in which writers of imaginative literature find most of their themes. The Germans call both prose and fiction *Dichtung,* very properly making no distinction between the two since in both the imagination is the dominant agency.

When the imagination is kept within bounds by the intellect it discovers many general truths. Even our senses are constantly deceiving us when uncontrolled by the judgment. This control is lacking in the insane and in brutes. A horse that shies at a piece of paper blown across its path is doubtless influenced by its imagination. Its primal instinct is self-preservation and the unusual object portends danger. An unaccustomed noise or smell often produces the same effect.

Fiction, including poetry, is generally the production of a kind of unsystematic meditation in which successive steps are not logically correlated. These steps are the result of association, or suggestion and reintegration. If they follow each other in strictly logical order they could exhibit but little variety, perhaps none at all. Often a word or an idea brings into the mind another idea or concept that has a merely accidental connection with it. The process can not be foreseen because it is not alike in any two individuals. Neither can it be retraced or repeated, which may always be done when a chain of reasoning is strictly scientific. It usually has no very definite purpose and is rarely based on definite knowledge. In fact, definite knowledge usually dissipates a state of mind that does not differ widely from delusion. "Poetry," says Wordsworth, "is emotion recollected in tranquility." The scientist always regards emotion as a disturbing factor. It prevents his seeing objects as they are. Emotion interferes with clearness of vision and distinctness of mental apprehension. It is wont to endow objects with qualities which they do not possess. There is a vast difference between a slight possession and a deep-seated and ineradicable prejudice; but every step from one toward the other, no matter how short, is a movement away from the truth. Most men are more emotional in early life than in later years because experience and reflection enable, and often constrain them, to see persons and things more nearly as they are. An emotional state of mind in its intenser form is usually called enthusiasm. Carlyle employs a semi-German word, *Swarmery,* as being more expressive. Under the influence of strong emotion almost every person becomes an enthusiast. But it is only men of genius who can produce this mental condition at will. Few persons can remain in the emotional state of mind for a long time because the commonplace affairs of the world demand frequent returns to the normal state. On the other hand, there are persons whose hopes and anticipations so persistently deceive them as to unfit them for the stern realities of this world. It is difficult even for genius to deal with conditions objectively, to envisage phenomena with the clear apprehension that its own personality is a disturbing factor. In persons endowed with a literary mentality there is developed the style of an author, that is, his individual mode of presenting his thoughts to the reader. Every author of note exhibits this characteristic. Hence it is generally possible for experts to divine the authorship of anonymous literary works. The late James T. Fields recognized some of De Quincey's unsigned essays which he found in periodicals; and although their author at first declared he was mistaken finally admitted what he had himself forgotten. Great as were the intellectual endowments of Byron and Goethe, commentators on their works profess to be able to discern their personality in everything that emanated from their pens. They were unable to get away from themselves. They viewed the external world through a medium which they could not lay aside. It is interesting to note the improvement in the esthetic taste the human psyche gradually underwent after men began to reflect upon their mental processes, although this improvement was doubtless at first unconscious. Homer describes minutely the harnessing of mules to a cart and the killing of animals for sacrifice. Furthermore, he exhibits a veritably diabolical ingenuity in devising ways by which men might be mutilated and slain. When their passions were aroused the historical Greeks were bloodthirsty to a degree. They sometimes put to death by thousands their prisoners taken in war. The political factions showed no more mercy than do those in some of the Central American states. Their judicial tribunals were often frightfully unjust. But when they calmly looked upon a tragedy they did not want to see any one openly slain. The Æneid of Virgil, though largely patterned after Homer, is pervaded by a much more humane spirit than the Iliad or the Odyssey. Yet the same Romans who read it with delight found pleasure in witnessing the gladiatorial games in which men and beasts lacerated and killed each other for the delectation of the spectators. During the middle age and far into modern times when religious persecution claimed its wretched victims by squadrons, the execution of human beings was often accompanied by the most frightful atrocities amid the applause or the silent approval of the spectators. But the modern novelist or poet who deals with these gruesome ages passes lightly over the more revolting incidents and permits the imagination of the reader to supply what he darkly hints at. Victor Hugo describes in minute detail, largely from his imagination, the slaughter of men and horses in the "hollow way" at the battle of Waterloo. But he casts a sort of halo of glory over victims and vanquished alike by extolling their bravery, their devotion to duty, their disregard of wounds and death, in order that he may arouse in the minds of his readers a sort of enthusiasm which makes him forget the horrors of the scene. The modern novelist is usually careful to eliminate everything from his production that would offend the esthetic taste, even to the extent of perverting well-established historical facts. "Egmont" is one of Goethe's most popular dramas; but its hero and the Egmont of history are totally different persons. The same may be said of Schiller's "Tell," by most persons regarded as attaining the highest excellence in German tragedy. Many of the eighteenth-century novels are now but little read by reason of their coarseness, while such a simple story as the "Vicar of Wakefield" is as popular as ever. While, therefore, the general progress of events did much to humanize men, the movement was very slow, with many and long periods of stagnation, between about 400 B.C. and A.D. 1800. Persons of insight had learned to be humane before science had taught them the wisdom of humaneness. Science had made considerable progress before the latter date. But it was aristocratic. The common people concerned themselves little about it because it taught them almost nothing which it was to their interest to know. It dealt chiefly with large problems, not with the minute affairs of daily life. The fundamental difference between science and poetry is that the former seeks to know and to set forth the truth no matter what the consequences; the latter seeks to give pleasure. Coleridge says:

> Poetry is not the proper antithesis to prose, but to science. Poetry is opposed to science, prose to meter. The proper and immediate object of science is the acquirement or communication of truth; the proper and immediate object of poetry is the communication of pleasure.

Hence the poetic justice that plays so important a part on the modern novel is not the justice that prevails among men. Science brings before us the stern facts of the world in which we live, painful though they may be. On the other hand, imaginative literature either ignores those facts that pain the reader or weakens their effect by contrasting them with man's nobler traits or with human nature in "her calmer moods." Often a disagreeable subject is placed at a distance from us in either time or space. The Homeric poems are full of strife and slaughter and bloodshed and treachery; but they also portray conjugal and parental affection, valor, friendships that are not broken by death, piety toward the dead, fortitude and heroism. A novel in which all the characters are bad would be read by nobody. The popularity of Scott and Dickens is due mainly to the humanitarian spirit which their works display. They portray villains of the blackest type, but they always meet with the reward which we feel to be their due. Such novels are, therefore, not true to nature. Many knaves live to enjoy the fruits of their villainy to the end of a long life and die in peace. To the scientist nature is "red in tooth and claw"; to the poet she is a benignant mother, a provider of pleasure and a beneficent friend. A truth is often clad in a poetic garb. It then becomes a winged word, and impresses itself more firmly on the mind. It is poetry as well as truth. When Burns wrote: "O wad some power the giftie gie us," he put on a homely truth a poetic garment. On the other hand, the commonplace and unadorned dictum: "Honesty is the best policy," together with a thousand similar proverbs lacks every element of poetry. It is the embodiment of human experience, a sort of summing up of what men have learned in their intercourse with one another. It is science. Proverbs are the small blossoms on the large tree of human experience. There exist odes to the skylark in every language spoken where this bird is known. No two of them are alike. But all descriptions of the skylark by ornithologists agree in the main. Carlyle often expressed disgust for "silly poetry." Yet he generally dealt with the facts or the reputed facts of history from such a strikingly individual point of view that a great deal of what he wrote belongs to the realm of the imagination as much as to the domain of history. He could not get away from himself,—probably did not want to. "Romola" or "Jane Eyre" deals with types and not with individuals. Their authors probably had some one in view for almost every character they introduced. But they are disguised. On the other hand, some of Carlyle's heroes are historical characters and bear well-known names. Nevertheless, they are almost as much unlike the familiar men and women of the ordinary text-book as if they belonged to the realm of fiction. The type never exists in unadulterated form. Very few every-day people are interesting. Consequently, when novelists bring them before their readers they exaggerate both their virtues and their vices in order to make them attractive. Dickens has a great deal to say about schoolmasters and schools. It is nevertheless much to be doubted whether the men and women he describes and the conditions as he represents them existed anywhere in England. By taking here and there from this person and that a trait or a personal peculiarity that best suited his purpose he makes composite portraits and portrays characters with such verisimilitude that we forget that they are largely the creations of his imagination. Albeit, the imagination is a wonderful and mysterious faculty. The orator is to some extent an artificial product; the poet is born. Unlike the intellect and the will, the imagination can not be trained. Dickens was almost without education; yet he portrays in his works fifteen hundred and fifty characters with more or less fulness of detail, while the number of names of places, societies, literary works, familiar persons and signs exceed two hundred. Balzac's works contains two thousand biographies, individual, distinct and, for the most part, complete. He usually takes each person at his birth and does not lose sight of him until his death. He also knows what the spirit of the country was in their time, the condition of the provinces and the trade to which the man belonged. He even knows what his income is, what taxes he paid, and the state of his culture. Yet Balzac's productive years hardly exceeded a score and Dickens died before reaching old age. In rare cases, but probably in more than is generally known, the poet and the scientist are combined in the same person. The Rev. C. L. Dodgson was a mathematician of considerable ability and expected his fame to rest on what he had done in this department of knowledge. Now hardly anybody cares for his mathematical writings while there are few who do not find "Alice in Wonderland" exceedingly interesting. The little volume is so "excruciatingly silly," that we laugh over its absurdities without knowing why. Goethe was probably the only poet of modern times whose fame is world-wide and whose work in science was of a high order. But as science is progressive many of his ideas have become a part of its history and may be said to be outgrown. Moreover, as the world can not or does not believe that a man can be great in more than one or two departments, Goethe is known as a man of science only to specialists. Then too the interest in facts is confined to few, while fiction is attractive to the great mass of mankind. The late Professor Shaler was a man of similar type. He ranked high as a scientist and wrote dramas that contain many notable passages. But this sphere of his mental activity is not generally known. It is probable that no man engaged in research and investigation is a scientist "all through." Benjamin Franklin is an interesting case. From his earliest youth he seems to have had his mind almost exclusively on practical matters. Albeit, under the influence of Whitefield's fervent appeals he emptied his purse into the contribution box in spite of his first resolution to give nothing, then to give at least very little.

Many persons seem to be unable to distinguish at all times between the products of the imagination and concepts based on observed phenomena. Sir Isaac Newton is regarded as the founder of mathematical physics and physical astronomy. We are astounded at his marvelous intellectual acumen when we consider the inadequate instruments with which he had to work. Yet he devoted much time to theological speculation and wrote many pages that are mere puerilities. So feeble are they that M. Biot professed to believe that they were the productions of his dotage. But he was mistaken. Newton also spent a good deal of time on the writings of the alchemists and tried to discover the philosopher's tincture. There was evidently a large measure of the mystic in him. There was a good deal of similarity between his mind and that of Swedenborg. In many things the latter was thoroughly practical and a master of much useful information; but his mystical vagaries often led him far astray. To such an extent did Kant find this to be the case that he characterized him as the prince of visionaries. Sometimes men adhere to a creed adopted in early life and refuse to modify it no matter how much new evidence is brought to their attention. It is usually easier to defend an accepted belief because we have the materials ready to hand than to test the data which might lead to its abandonment.

Charles Darwin relates, in his autobiography, that up to his thirtieth year he was very fond of poetry, and even as a schoolboy took great delight in Shakespeare. But in his later years he could not endure to read a line of poetry, and on attempting to reread Shakespeare's plays found them insufferably dull. On the other hand, he experienced great delight in reading novels, or in having them read to him, if they did not end unhappily, "against which a law should be passed." Many scientists, however, have held a different attitude toward poetry. J. S. Mill, although not a scientist in the strict meaning of the term, possessed a severely logical mind. When his premises were correct his conclusions have rarely been called in question. In his autobiography he says, when speaking of Wordsworth:

> What made his poems a medicine for my state of mind was that they expressed not mere outward beauty, but states of feeling and thought colored by feeling, under the excitement of beauty. I needed to be made to feel that there was real permanent happiness in tranquil contemplation. Wordsworth taught me this, not only without turning away from, but with greatly increased interest in the common feelings and common destiny of human beings.

Quite as remarkable both for what it was as for what it was not was the mind of William E. Gladstone. He is said to have been the only English statesman who could make a speech in Parliament two or three hours long crammed with statistics and bristling with figures yet hold the attention of his auditors to the end. Some of his contributions to the history of ancient Greece are considered to be of lasting value. On the other hand, in his controversies with Huxley and in his theological writings generally he displays such short-sightedness and such an obliquity of intellectual vision that the reader is sometimes prompted to ask himself whether Gladstone the statesman and Gladstone the theologian are the same person. Horace observed long ago that you might drive out nature by violent means, but it would always return. Although Darwin's mind seemed to be almost pure intellect, he was a man of kindly disposition, of strong feelings and wide sympathies. Many anecdotes are told of the ways by which his grandchildren tyrannized over him. Herbert Spencer was unable to suppress feelings of indignation when he witnessed an act of cruelty. He was powerless to explain this emotional state of mind and admitted that he could not help it. It is not putting the case too strong to say that every forward step in the march of human progress has been due to the constructive or creative imagination. In the man of routine it is very feeble, so feeble that it can hardly be said to exist. Columbus imagined the existence of a continent at some distance westward from the Atlantic coast as he knew it because he saw on the shores of Portugal branches of trees, two human corpses and other objects which he was convinced were not of European provenience. Many other persons had seen similar objects before him; but they did not set the imagination of the observers to work. In addition he had doubtless read the views of the Greeks as feebly reflected in a few Roman authors affirming that the earth is a sphere. Had his imagination been of the fanciful order he might have written a poem or a novel the characters of which would have been the inhabitants of the western coast of the Atlantic. He might have given to the world a prototype of "Peter Wilkins," or of a "Journey round the Moon." If he had been on bad terms with everybody he would have produced an early version of "Gulliver's Travels," for which his experience with men would have doubtless furnished him much first-hand material.

The imagination performs an important service to mankind when it takes the form of sympathy. This is an emotion that scarcely exists among the lower animals. When some of the individuals of a flock of birds or a herd of beasts are injured or killed their companions pay no attention to them or take flight. The compassion shown by man for his fellow-man can not be explained solely on the ground of selfishness or self-interest. It exists where this motive can have no conscious influence. To be human and humane mean nearly the same thing. But the sympathetic emotion avails little unless directed by science. Those who are suffering from disease or injuries are not as much benefited by the active sympathy of a hundred ignorant persons as by the knowledge of one who knows how to alleviate their ills. The ravages of disease were not checked until science discovered their causes and preventives. It is one thing to bewail the sad lot of man, as has so often been done in both prose and verse, and quite a different matter to teach him how to better his condition.

The imagination performs an exceedingly important service in the sphere of human activity when it is called hope or expectation. Mark Akenside wrote an interesting poem on the "Pleasures of the Imagination" and Thomas Campbell a fine one on the "Pleasures of Hope," in which these emotions are dealt with from the standpoint of the poet. It must be admitted that they embody much of truth. The man who has no expectations and is no longer lured by hope has outlived his usefulness. There is little in the future that can be called certain, when it depends on human conduct. Action is usually conditioned by hope and the most vigorous action is inspired by the most ardent hope. But unless hope is enforced by a resolute will and guided by insight it rarely leads to tangible results. The alchemists were inspired by hope, but most of their labor was fruitless. The Spaniards sought the fountain of youth and El Dorado, but found only disappointment and suffering and death. Imaginative literature that keeps close to facts is a European product; and Europe has made more progress in a hundred years than Asia in a thousand. Nobody but a European would think of writing a "Treatise on the Creative Imagination." Nor would an Asiatic be interested in the pleasures of hope or of the imagination. The Chinese who have the reputation of being the most practical people in the world have made more progress in the last two decades under the guidance of science than in the preceding two thousand without it. The imagination is the force that impels the scientist to seek new and hitherto unexplored regions in the vast domain of nature; but unless it is guided and controlled by the intellect it rarely leads to anything worth while.

Perhaps, however, the circumstance that our generation devours enormous quantities of fiction should not be taken as evidence that there is comparatively little thinking. Mental effort is largely expended along practical lines. Such problems as the existence of God, the priority of mind or matter, whether moral ideas are intuitional or evolutionary, metaphysical monism or dualism, together with a host of others on which philosophers were wont to expend their intellectual energies for more than two thousand years are now generally regarded as impossible of solution and are ignored. The world concerns itself little about transcendental questions and is turning with increasing interest to the consideration of matters that lie within its reach. Everybody now admits that the noumena of the cosmos are undiscoverable; the use to which the visible and tangible phenomena about us determines our moral and physical welfare and our mundane happiness as a whole.

# THE RURAL OPPORTUNITY AND THE COUNTRY SCHOOL

By JOSEPH WOODBURY STROUT
REHOBOTH, MASS.

THE rural community is the granary of the world. Civilization is not possible without the farmer. The great city could not endure without the country. This feature of the economic situation is just now making itself prominent. The rapid increase of population in the cities naturally means decrease of population in the rural districts, which, in turn, means decrease in agricultural area, so that, while pro rata, increased products of the soil are demanded, decreased products are the facts. At least there is no marked increase of the food product of the world. These conditions bring the rural district to the front as holding the key to the situation.

But the rural community is not only the granary of the world, it is also the sanatorium of the world. In the fight against disease nothing counts for more than pure air, wild storms of wind, and isolation. This asset can not be measured in dollars and cents. Here also, the country becomes indispensable to the city. Hospitals and homes of all kinds, now, are pushing out into the country and gathering upon the hills. God's great out-of-doors is with the farmer, and medical science is making the largest possible use of it in that direction. The opportunity here opened for the rural community to fill a large place in the world is wide and deep.

Still another and perhaps greater opening before the rural community is its possibility to reform the boys and girls, stray waifs from the city, that are now being colonized in the country. Massachusetts has about abandoned her larger institutions for homeless boys and girls for the purer atmosphere of the farm home. Children of such type can be better managed in the country where they are isolated than in an institution where a hundred or more are segregated. Besides, the farmer, usually in need of boys, seldom fails to greatly benefit these waifs, and sometimes makes good citizens of them. I can point to a number of instances where excellent results have been obtained, and boys on their way to the penitentiary, and girls to the reformatory, have been lifted to higher planes of moral energy, trained often to take the initiative in large activities, meanwhile making for themselves homes of comfort and love. The opportunity is before the rural district to lift a large part of the world to new life, and to give new energy to that part of the world which is left.

Above all, in the greater persistence of rural family life, the greater stability of the marriage tie, the consequently larger family, the rural community forms a surer foundation for the future than the city. Professor Carver, in his "Principles of Rural Economics," says:

> The rural family is a stable institution, whereas the city family has become a relatively unstable one. The divorce rate is much higher in the cities than in the country districts. The city family tends to die out through celibacy, sterility and various other agencies, whereas the rural family persists. The farms not only feed the cities with their material products, but they also furnish the cities with men and women.

All this is within the possibility of the country community; in many ways, has always been, and now is pressing for recognition as a noble opportunity, yet it is here that the community has most signally failed. Some things along this line naturally are to its credit, but they are few, and compared with its possibilities and opportunities, seem insignificant. The locality that might render the world such high service seems oblivious to the demand. Knocking at its door to-day, asking for food and shelter, for new vision and higher planes of physical and moral energy, stands a great age, while the men of the rural community remain unseeing, unbelieving, timid, indifferent, almost antagonistic. The rural district is greatly hampered with an inheritance of social customs that well nigh negative any new thought, or hope, or plan. Its circle of thought is narrow, its plane of energy is low, and it easily wearies of any reform. On the other hand, the city is awake with vital energy. In his "Energies of Men," the late Professor James says:

> City and country people illustrate the difference between men who are energizing on a high and a low plane of life. The rapid rate of living, the number of decisions in an hour, the many things to keep account of in a busy city man's or woman's life, seems monstrous to the country brother. A day in Chicago or New York fills him with terror. But settle him there, and in a year or two he will have caught the pulse beat. And he will have come to enjoy this tremendous life.

That is, he will have climbed to a higher plane of energy, and is now using more of his possible power, living more nearly his larger life than before, and is a stronger man. But if the man from the rural district, under the city stimulus, can rise to a high plane of energy, may he not also do that at home, in the midst of his native environment?

The rural community must rise to these higher planes of energy and cultivate its great waste opportunities. It must learn that on its new birth, in the last analysis, the world of men and women are mainly resting their hopes for the future, not only for comfort, but also for life itself. Furthermore, it must learn, that, not only in the line of food, or in the way of health and happiness and reform, is it a necessity of the world, but also, in the possibility that its farm homes, in simple and subtle ways, by healthy, natural processes, may develop within their own narrow limits many a strong soul, many a great man. This community can take the unfortunate, morally and mentally bent boys and girls from the crushing life of the city, and, under the clearer skies of a simpler life, by injecting more of the time element into their education, make them into new and wholesome men and women. It can stimulate its own boys and girls to higher ideals and larger views of the world, and by arousing itself to this mission the community can not fail, in large measure, to recover its own lost grip on the wider world.

A great day for the rural district is clearly at the front. Are the people of these localities awake to the opportunity? It is because I think I can answer the question in the affirmative that I am writing this article. But, given the appreciation that a great opportunity is at their door, the next movement is to grapple with it, and master it. That such may be done, the people will be compelled to make some marked changes in their thinking, and in their method of work. Here strong and wise leadership is called for. After the minister, no man has more nearly in his own hands the uplift of the rural district than the schoolmaster. The school is a power plant for intelligence, vision, training, and manhood. It is for use. And wisely used must render great help in solving the rural problem. But the school board, and the schoolmaster of the country districts, must rise to a higher and more intelligent plane of energy if they are to count in the new life of the community.

Our age may well be termed a renaissance. But in that character it has only just begun to dawn on the small and scattered sections of the country. There came a day in the fifteenth century when Italy renewed her youth. A new and mighty impulse to nobler ideals stirred the nation. Slumbering instincts aroused themselves, and songs of the spirit, unsung since the ancient empire passed away, became once more a joy and a glory. New songs were sung. The imagination reasserted itself, and the mind recognized a deeper and diviner significance in life. It is called the Italian renaissance, the rebirth of literature and learning and art in Italy. This awakening placed the nation on a high level of intellectual and spiritual energy where she soon demonstrated to the world that, in herself, she possessed an age, greater, in some respects, than that of Pericles.

But the rebirth of Italy was no miracle. It did not come in a night. It was largely the product of the schoolmasters. At least it involved the elements of learning and scholarship. The stimulus indeed was from without, being the discovery and possession of Greek literature and art, but in reality, the secret of it was in the stored energies of the people. It was the uprising of long dormant forces in the heart of a great nation. A miracle is not demanded to bring new visions and new energies to the rural community. It is only necessary that they hear their call, and realize the need of developing their own deepest life. And in this it is only needed that they begin low enough and gradually rise to the mastery of their mission. In this the schools are indispensable. But to do its legitimate work the school must be manned with teachers who feel a divine call to service. That, in turn, calls for a school board with imagination and vision. Here the dearth is deep. The rural school is in poor condition to render much service, while the service demanded is great. The task of the teacher is to open new visions, to arouse deeper energies in the pupils, and through them to lift the ideals of the community, and to make the people hear the call of the times. The men must be shown how much possible energy, of a high order, right within their own district limits, is lost to the community and to the world because the boys and girls are not made to realize the value of more and better training, or kept in school long enough to find themselves.

This school is suffering sadly from social heredity. Thirty years ago I taught the winter school in a rural district down by the sea. It was in the proverbial red schoolhouse, in the center of the district, being a mile from the nearest inhabitant, in a grove of spruces through which the sunlight, save in little streams and eddies, never came, and directly opposite the village burying ground. A gloomier spot, or one less fit for a schoolhouse, it would be difficult to imagine. At the opening there were sixty-five pupils, ranging in ages from four years up to twenty-five. There were about as many classes, from the infant class learning their letters to the big boys studying navigation. The work went on according to the old customs and therefore was voted right. It could not have been very efficient. Three years ago I visited that school again. The schoolhouse, still red, stood in the old grove of spruces, sunless and damp, still fronted the north pole, the graveyard was still across the road, and not yet any sign of playground in sight. Some things had changed. They were having three terms of school instead of two, and all were taught by a woman. The pupils would not average as old as mine, emphasizing the growing tendency to drop out early, and there was no real attempt at grading, least of all any effort to put the school on a basis where it could better serve its own peculiar community. The lads, who, through the season, hauled lobster traps and seined mackerel, or cut stone in the great island quarries, were learning nothing about the sea, or the fish, or the stone formation of the island, albeit many of them had already chosen one of those lines of work for a life calling. The old class in navigation had dropped out. Twenty-seven years had marked few changes and no real advance.

And this is not an extreme case, either. Quite every rural school is failing in plan and purpose to exploit the vital needs of the community. I have examined a great many rural schools, making careful note of the text-books they used. These books, in general, are quite in a foreign tongue. They possess literary value enough; the arithmetics contain an abundance of problems for training in railroading, manufacturing, brokerage, banking, insurance, the grocery business, what not, but only now and then an example on surveying, or measuring wood, and nothing whatever on mechanics and agriculture. The vocabulary contains some words that are in use in the district, but not the terminology in which the community is thinking and exploiting its hopes and fears, its ambitions and ideals, especially its practical life.

A light-keeper on one of the Maine islands, years ago, as I landed from a lobster smack to teach the winter school, said to me: "I am glad to see somebody who can talk something besides lobsters and mackerel." This island was engaged in those industries, and had one of the largest fleets along the shore, and was becoming a prosperous community. Naturally they talked "mackerel." In the schools, however, mackerel and lobsters were tabooed. They used the common text-books, containing about everything except what nine tenths of the pupils needed most to learn. I tried to obviate this omission by making problems directly related to their home industries, by teaching something about the resources of the ocean, the habits of its denizens, and kindred subjects, but to no purpose, for, immediately, I was overwhelmed with curt notes from irate mothers, saying: "We get enough talk about 'mackerel and lobsters' at home, without having it taken into the schools. Our men talk 'mackerel' all day and half the night, and we can't stand it to have the children take it up." Yet I had taken up the theme in a very different way, trying to cast about it enough of science and romance to take away the odors of familiarity, but they would have none of it. Fathers said to their boys: "Don't follow the sea. Its a dog's life." Mothers taught their girls to seek life in the larger towns and cities. Anything but the life by which they were winning their bread. They discouraged the hope of finding a larger life in their island wealth and the resources of the surrounding sea, and sent their boys and girls to the city.

The rural communities hitherto failing to row their weight in the economics of the world, now finding themselves dropping astern, are entering complaint of unfair treatment in the social and industrial distribution. This however may be a hopeful sign, for men are thus compelled to turn their attention to the conditions underlying the situation. In such an examination they can not fail to discover that there is great waste in these country districts, not only of land, but more striking and important, great waste of human energy. The girls and boys are not educated. The rural community has never made a just estimate of human values. Its values are in land and cattle, boys and girls are a kind of necessary nuisance. At the most, after twelve or fourteen years of age, they are left to train themselves. The community has never been willing to finance the chances of these boys and girls by manning the schools with teachers of large enough caliber to hold them through the eighth grade, or to develop the possibilities of their lives for strong and useful careers. If such communities are ever to assume their normal burden in economics, or the social life of the world, their boys and girls must be carefully trained in the schools.

These communities have not only lost their best men to the city, but they have never tried to make the most of those who remained at home. Here is the opening for the schoolmaster. He must gather up the waste material in the persons of boys and girls, and by enriching and prolonging the course of study, hold them in the schools until they have obtained something like a fair knowledge of the elementary necessities of a life work. Now, the larger number of rural boys and girls leave school at the end of the sixth or seventh grade. If a boy hangs on a little longer it is because his parents force him to, and it is often at the expense of his self-respect, for he must go on with younger pupils. He is now twelve, or thirteen years old, and feels that, although staying in school, he is not getting anywhere, while he might be at work earning money.

After the seventh grade the rural school is well-nigh chaotic. It is pretended, by some school boards, that the full eight or nine grades are taught, but the wholesale manner in which pupils from these schools are turned down in the tests for the city high schools rather negatives the claim. The following figures taken from the government school report for 1903 are eloquent with misgivings. After the seventh, for the whole country, 20 per cent. of the grade drop out of school. But in the rural districts, where the seventh grade virtually finishes the course of study, the number dropping out is over 50 per cent. of the grade, which not seldom means all of the boys. The girls linger a little longer. Here is a waste of energy, a loss of vital possibility for which any amount of money saved can not compensate. Boys leaving school at such stage have not obtained the elements of a common education.

Still the country school has possibilities. Raised to a normal standard, generously equipped, and strongly manned, it can do much to redeem the waste and apathetic life of the community. It possesses the initiative of a renaissance, but it must be made the most of. In order to accomplish such result a great many customs must be readjusted to a new day and its larger environment. In this readjustment we must be sure and begin low enough, by giving thought to what hitherto has seemed insignificant, namely, the careful location of the schoolhouse, and its orientation. The school building should be in a dry, sunny, sightly spot. Ordinarily it should face the southern compass. This would move seven tenths of our rural schoolhouses, and turn more than half of them end for end. It is not at all necessary that a school building should face the road, or be very near it. Light, warmth, horizon, room to play, these are the important considerations in locating a schoolhouse. Play, in the rural districts, is almost a forgotten art. No provision is ever made for it. No ball grounds, or tennis courts, or croquet lawns, are ever seen near the rural schoolhouse. The boys get no training in team work, or athletics. The community has yet to learn that a boy's play is a vital element in his education. Here, in the location and layout of the school grounds, is the first use of the rural school for community uplift.

Moreover the curriculum of the rural school is faulty. It has been kept at odds with its environment. In the midst of trees and flowers, birds and bugs, the child has been held down to a study of words and forms, and figures, not much related to his common life, and at the best too abstract for him to digest. He learns nothing of agriculture, mechanics, or biology. The children are not taught to study nature, or, in the least, directed or instructed in their play, except in a few instances. Nothing of manual training, even in simple forms, is ever attempted. These things have been crowded out by the old-fashioned literary curriculum. While there need be no neglect of reading, writing, spelling, or arithmetic, still, it is true that "these ought ye to have done and not to have left the others undone." Indeed, I would add to the reading and writing, together with the elements of agriculture and nature study, a systematic culture of memory selections, little enough of which have I found in any school. But it calls for a teacher of culture and training to make and exploit such a curriculum. Here the teacher is of paramount importance.

The teacher must be capable of leadership in the community. For, although these pupils may be learning only the elements, they must still be shown, at the right time, the wider world, in unison with which, when at their best, they also are moving. There must be opened to them a world of deeper significance than that commonly seen. They must be taught to feel the throb of a universe in the pulse beat of their own hearts. They must be filled with enthusiasm for life. This calls for a teacher of large caliber, of rich culture. It is a blunder, as well as a waste of money, to select teachers for the rural schools, as is now largely the custom, from the graduates of the high school. No one ought to be employed to teach a country school who is not a graduate of college, or trained in the best normal schools, or one who, by industry and experience, has gained an equivalent for such culture.

Then, after the seventh grade, the schools would become much more effective if they were centralized. The old district system has not lost all of its value, for the first six grades, or perhaps seven, can be taught in the old schoolhouse, providing that schoolhouse be rightly orientated and equipped with playgrounds, and other necessities, quite as well as in the center, and the children are within their mothers' reach. But the next upper grades, in the rural community, must be centralized, strongly manned, with an adequate curriculum. Here manual training and elementary agriculture, can be taken in hand, and when this is done in earnest and with skill and enthusiasm, it becomes interesting, and by its appeal to the boy's larger self, holds him longer in school.

But the rural district needs a high school. It may be true that no rural community can equip a school that would compare with the city high school, where, now, some of the boys and girls are sent; nevertheless if it would take its own place in the world, the rural community must have its own high school. For it is not the boys and girls that are fitting for college, financed and forced by their parents, who create the school problem here, but the boys and girls who have not so much as heard that there is a college. It is the large number of pupils that might attend high school, and possibly go up to college, were a high school nearer home involving little, or no expense, and for which, to some degree, their fathers were responsible, who complicate the school problem, and make it vital. No one can conjecture what talent, or slumbering genius even a year in the high school might develop in the dullest boy. And it is the possible boy and man who must be provided for. The waste of possible men and women of greater parts than the common life bears witness to among the farmers is great and sad. In the face of so much latent energy of the highest kind, the talk one hears about the expense of the thing is utterly unworthy of an intelligent community. It is indeed true that the farmer has suffered from the tax system of our government more than any other class, but it is not so much demanded that more money shall be raised, as that what is raised be more intelligently expended; so placed that it can make returns in character and in life.

Now that the world, once more, is waking up to the fact that the rural community is an absolute necessity in the economy of civilization, a splendid opportunity opens before the schoolmaster to make himself felt. Here the schoolhouse may become the power house of a higher life. But the master must have the training necessary to reach the practical element in these problems; he must be able to meet the boy's need of a dignified curriculum, and he must possess in himself a never-ending fund of imagination, of enthusiasm, and of long vision. Given such a man backed by a well-equipped schoolroom, and the community has a powerful asset towards grappling with the new life of the day, and meeting the economic, political and moral demands now being made upon it.

# EARLY GEOLOGICAL WORK OF THOMAS NUTTALL

By Dr. CHARLES KEYES
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WHEN, in England about a century ago, earth-study was made a modern science through William Smith's famous geological discoveries that the relative age and natural sequence of rock-layers were susceptible of accurate determination by means of the contained organic remains, America very early, and from a wholly unexpected quarter, furnished important aid in support of the newly established principles. The circumstances were long since all but forgotten. In the few casual references made to them in latter years either their significance was misunderstood or familiarity with the attendant conditions was entirely wanting. As the first successful application of modern geologic principles in the New World the episode must ever remain of greatest historic interest.

Singularly, this primal American effort to correlate by their faunal contents geologic formation widely separated geographically was not made in that portion of our continent which was most accessible and where it was most natural to expect it—that is, along the well-settled Atlantic border—but it was in the then remotest section of the upper Mississippi valley. First fruits of research and observation were obtained in a region which was then perfect wilderness, but which now forms part of the great and populous state of Iowa. Moreover, these remarkable observations were made within a decade of the time when the novel method was originally announced in England. They antedated by fifteen years Samuel Morton's similar effort on the Tertiaries of our Atlantic coast commonly regarded as the maiden attempt in America along these lines. By two decades they were in advance of the first work of that pioneer American paleontologist, Lardner Vanuxem. They anticipated by a full generation the famous investigations of Thomas Conrad and James Hall in New York. Indeed, they were the means of actually and correctly interpreting the true position and biotic relations of the Carbonic rocks of the continental interior a half century before their geologic age was otherwise generally admitted. The Mississippian limestones, as the rocks are now called, remain to-day as compact and as sharply delimited a sequence of geologic terranes as they appeared when first recognized in that memorable summer of the year 1809.

This successful use in America of faunal criteria for purposes of solving problems of geologic correlation and of identifying geological formations was the first real ray of modern light to penetrate the stratigraphic darkness shrouding the New World. The happy application of these criteria was due directly to the keen scientific perception and peculiar reasoning of one who was never known as a geologist at all, but who was raised to fame through a wholly different channel of scientific activity. The name of this truly remarkable personage was Thomas Nuttall, botanist.

Nuttall's extensive travels in America were undertaken chiefly in the interests of his monumental works on North American plants and of his valuable contributions to American ornithology. On his first great trip, after traversing the southern shore of Lake Erie, and coasting by canoe Lakes Huron and Michigan, he entered Green bay, and, following that famous all-water route to the west which the Indians had used from time immemorial, ascended Fox river to the short portage to the Wisconsin river, down which latter stream he floated to its mouth, near Prairie du Chien, thence down the Mississippi river to St. Louis. Subsequent trips took him far up the Missouri and Arkansas rivers.

On his Mississippi venture besides garnering great quantities of interesting plants and taking voluminous notes on the birds, he appears to have made extensive collections of the fossils which he found throughout his path abundantly scattered through the limestones which in high cliffs bordered both sides of the great stream. In the course of his explanations of the geologic features of the region through which he passed Nuttall naïvely notes that he is "fully satisfied that almost every fossil shell figured and described in the 'Petrifacta Derbiensia' of Martin was to be found throughout the great calcareous platform of secondary rocks exposed in the eastern Mississippi valley." Thus by means of fossils he parallels these limestones of the Mississippi river with the mountain limestone of the Pennine range in Derbyshire, England, to which, several years later, Conybeare gave the title of Carboniferous.

Along the Mississippi river, as we now know, Nuttall really encountered little else than rocks of Early Carbonic age, so that his identifications of the fossils were doubtless, with very few exceptions, correct. Moreover, at this date and for some time afterward, the lower portion of the exposed stratigraphic sections, it must be remembered, was entirely undifferentiated, the great sequence of older beds which were subsequently separated from one another being jumbled together under the title of Transition group. It was not until more than a quarter of a century later that out of them, in Britain, Murchison and Sedgwick established the Cambrian, Silurian and Devonian systems.

Another important geologic correlation is to be credited to Nuttall. On his journey up the Missouri river, in 1810, which he undertook with John Bradbury, a Scotch naturalist, he reached the Mandan villages on the upper reaches of that stream. He makes especial mention of the

Omaha village situated below the mouth of the Big Sioux river. A short distance upstream from the last mentioned point he examined strata which, by means of their fossils presumably, he refers to the Chalk division of the Floetz, or Secondary, rocks of northern France and southern England. This is the earliest definite recognition of beds of Cretacic age in America. It preceded by a decade and a half the separation, by John Finch, of the newer Secondary rocks from the Tertiary section in the Atlantic states, and Lardner Vanuxem's and Samuel Morton's references of the same deposits to the Cretaceous age. Thus also was another great succession of one of our main geologic periods discovered in a then remote part of our continent years before it was recognized in the East.

At the mouth of the Big Sioux river Nuttall fell in with an old trapper who described to him the great falls which blocked navigation at a distance of 100 miles up that stream, and who told him of the famous Indian pipestone quarries beyond.

The analogy established by Nuttall between the general Carbonic section of Iowa and the upper Mississippi valley and that of northern England was one of the important geologic discoveries in America. Its great significance was pointed out by Owen a couple of decades later. Its historical value grows with the advancing years. In the final recognition of a standard Carbonic section for this continent the sequence displayed in the Mississippi basin must prevail, since it is now generally conceded that the Appalachian succession of strata can never be considered as the typical development.

So conspicuously botanical in character are Nuttall's services to science that one can but wonder under what circumstances he could have obtained his keen insight into matters geological. Elias Durand said of him immediately after his death that "No other explorer of the botany of North America has personally made more discoveries; no writer on American plants, except perhaps Asa Gray, has described more new genera and species." Lists of his published memoirs and papers quite generally omit all reference to his recorded geological observations, probably because their importance could hardly be fully appreciated by writers in other fields of science. In the present connection our main interest centers on the transplanting so early to the interior of the American continent of Williams Smith's novel ideas concerning fossils. Brief reference to some of the early events in Nuttall's life seem to offer a clue.

Nuttall was born in Yorkshire, England, in the mountain limestone belt, and near the scene of Martin's famous labors on the Carbonic fossils of Derbyshire. He was early apprenticed to the printer's trade and after a few years removed to London. There he followed his trade until, at the age of 22, he set out for America, in 1808. He appears to have been a printer of the Benjamin Franklin order, since while engaged at his trade he became proficient in the knowledge of the sciences, Greek and Latin, and kindred subjects. During the period of six or seven years that he was in London he appears to have made the acquaintance of a number of the scientific men of the day. At least it is probable that at this time he acquired some familiarity with Smith's discoveries, which were at that date attracting wide attention from English scientists. It is also quite possible that Nuttall gained much of his scientific information through setting up the types for those very memoirs which have since become geologic classics. It is not unlikely also that he even met Smith, since the latter is known to have been often in London at that time, and to have taken up his permanent residence there several years before the printer-naturalist left his native country.

At any rate, Nuttall had been in America scarcely a year before he was putting his geological knowledge to test. His familiarity with Martin's "Petrifacta Derbiensia" and Smith's principles clearly indicates that he must certainly have acquired his information at least several years previous. Then, too, his acquaintance with that pioneer American geologist, William McClure, for twenty years president of the American Philosophical Society at this period, should not escape notice. Two other papers, partly geological in nature but chiefly mineralogical in character, on the rocks and minerals of Hoboken, and of Sparta, New Jersey, and the many keen observations on the rocks recorded in his journal of a trip from Philadelphia to Pittsburgh attest his unusual intimacy with matters in geology.

Notwithstanding the fact that the brief memoir which Thomas Nuttall published on Iowa-land and the contiguous regions was the only one which he seems ever to have printed on strictly geological subjects so important are the principles set forth for the first time in this single, simple, short contribution to the literature of American terranal correlation that it places its author in the front rank among pioneer geologists, not only of Iowa, but of our country. Although one of the foremost botanists of his day, and an ornithologist of world-wide reputation his great service in first pointing out by method and by means the fundamental concepts of modern historical geology in America should not be forgotten.

# THE STRUGGLE FOR EQUALITY IN THE UNITED STATES. III

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## Politics and Business

A common objection to political agitation is that it disturbs business, and either diminishes or renders uncertain the incomes of the laboring and property-owning classes. As an argument against agitation that is purely destructive, this objection is undoubtedly sound. To unsettle business without the prospect or possibility of sooner or later bettering working and living conditions is to render the existing situation worse and is therefore unjustifiable. But as an argument against agitation that is constructive the objection is footless. To urge people to submit tamely to things as they are is to argue that existing conditions are either as they ought to be or that they are incapable of being righted. Neither of these positions can be accepted. Moreover, to inculcate a fatalistic spirit would in the long run be bad for business itself. For the element in human nature that protests against injustice and contrives ways and means to overcome it is closely allied to the element that discovers defects in and improves the technique of industry. The fact that our age is not only highly inventive but also much given to social amelioration is more than a mere coincidence. Whatever lessens the latter is apt to deaden the former.

### I

A favorite argument in certain quarters is that if the business world were let alone it would reform itself without suffering the disadvantages which political agitation entails. This position is untenable. In the first place, the business world can not if it would leave politics alone. Business enterprise dependent upon franchises and corporate privileges inevitably drifts into politics. Wherever matters of public as well as of private concern are involved, the state is necessarily a party to the transaction. This is notorious in the case of the liquor traffic. So long as business men embark in enterprises dependent upon a protective tariff, they can not well complain if they become the victims of political agitation. Those whose interests are opposed to protection quite as much as those who profit by it are entitled to a hearing. Many of the questions which arise in connection with money, banking, railways, trusts and the relations between capital and labor can only be settled by political action. In foreign relations the state is the handmaid of business. Business and politics simply can not be divorced.

In the second place, the diversity of opinion in the business world itself is mainly responsible for the prolonged controversies that unsettle business. In our political contests, the business interests are not a unit. They are not agreed about reforming the currency or revising the tariff. In regard to the trusts, the small capitalists are opposed to the large. In the controversy over railway rates, many farmers, manufacturers and shippers have been arrayed against the railways. At times the railways have entered politics to prevent the large shippers from securing rebates by playing off one road against another. The agitation which led to the enactment of the Elkins law in 1903 is a notable instance. There is no such solidarity of interests among business men as the socialist doctrine of the class struggle would lead one to expect. Our industrial leaders compete scarcely less in the political than in the industrial field. Some of them enter politics to obtain favors for themselves, while others are compelled to enter for self-protection. The railway interest has occasionally been on the offensive and then again on the defensive in our politics. Business men are less in the political limelight than lawyers, but they are more frequently the moving power behind the scenes. There are no more persistent political strategists than many members of the business community. Without their support, many a professional politician would find himself out of a job, and the political agitation that unsettles business would have a very short life.

In the third place, more important than reforming business is the problem of keeping it on a high level, much as the preservation of health transcends the curing of disease, and what preventive medicine is to the public health "pitiless publicity" is to the level of business morals. It is only in a political atmosphere that is potentially critical that those in charge of large business can be expected to be on their good behavior. If every would-be agitator were put under lock and key, the tone of business life would undoubtedly sink to a lower plane.

Fourthly, the fact that business, if let alone, will reform itself is no argument against the use of means that promise to hasten the process, any more than the fact that a patient will in time get well proves that there is no use in calling in a medical practitioner. The doctrine of laissez faire has long since been discredited.

Fifthly, the disturbing effect upon business of political agitation that is necessary should be sharply distinguished from that which is unnecessary, and due account taken of the fact that the self-seeking demagogue is by no means wholly to blame for the latter. The obstinate shortsightedness of not a few men prominent in the business world is also responsible. In place of cooperating with well-meaning politicians in devising appropriate remedies for manifest ills, a studied attempt is frequently made to arouse opposition by creating a state of alarm. To this end the mildest kind of proposals are misrepresented by a subsidized press, the most sinister motives imputed to their advocates, and the possible ills that may ensue grossly exaggerated. The consequence is that much-needed reforms are sometimes delayed and the temper of the public tried until the foundation of the business order is undermined. It is not far from the truth to assert that certain opponents of the "Roosevelt policies" unwittingly contributed more to bring about the panic of 1907 than did the utterances of Mr. Roosevelt himself. The movement for railway control has made headway in the face of the most pig-headed opposition. A good deal of the time of the conservative reformer is taken up with denying allegations which he has no thought of entertaining. Mr. Lincoln, in the course of one of his debates with Douglas, said:

> I protest, now and forever, against that counterfeit logic which presumes that because I did not want a negro woman for a slave, I do necessarily want her for a wife.[13]

The foresight with which men of affairs are commonly credited often fails them when it comes to dealing with public opinion. This appeared in the tactless manner in which the coal operators treated the public during the anthracite strike. According to *The Commercial and Financial Chronicle,* the New Haven management in the acquisition of trolley lines in no wise strengthened the system, but laid itself open to the charge of trying to establish a transportation monopoly.[14] The fact that the business magnate frequently turns out to be a poor strategist in his relations with the public is no occasion for surprise. Intent on furthering the particular interests with which he is entrusted, he is apt to lose sight of the public interest and to do things which end in bringing down upon him a storm of popular disapproval. Positions of command tend to beget an undue sense of power and a supercilious attitude in one's relations with his fellows. The masterful spirit is often overbearing. The head of a large railway, industrial combination or public service corporation in a large city should be enough of a statesman to understand what the public wants as well as what is good for the general welfare, and in a democracy the man who feels that he belongs to a superior class is unable to understand his fellow men and is incapacitated for this service.

Sixthly, political agitation that is sane and efficient makes for business stability, or at least any ill effects are temporary and are far outweighed by the good effects that abide. It is easy enough to understand why bankers and others who deal with such a sensitive thing as credit view anything that unsettles business with alarm, but there is less excuse for failure to see that the cause of unsettled business is not the agitation which issues out of grievances but the grievances themselves. Reform that is genuine and real is the foundation of enduring prosperity. So

13 Debates of Lincoln and Douglas, *op. cit.*, p. 22.

14 July 12, 1913, p. 86.

averse is an influential portion of the business world to change, that this point is frequently overlooked or but partially recognized.

Amicable relations between the railways and the shippers could not exist so long as unreasonable discriminations were practised by the former. In granting franchises, the public can not be expected to acquiesce unless its interests are properly safeguarded. The passage of the Allen bill by the Illinois legislature constituted a challenge to good citizenship, and there could be no peace until the objectionable bill was repealed. The painful working out of the franchise question in Chicago and Cleveland has placed the street railway securities of these cities on a sound and reputable basis. The report of the commission appointed by President Roosevelt has made for peace in the anthracite coal fields. Not until the tariff is rescued from the hands of special interests and is settled to the satisfaction of the country will the business community know upon what to count. So far as legislation is concerned, much political agitation is either fruitless or results in unwise action. Due credit should, however, be given to an important by-product, namely, the stimulating effect upon the correction of abuses by voluntary action.

## II

Modern industry repeatedly adjusts itself to new conditions with surprising ease, and those in charge of any business are frequently the first to protest against a proposal to return to the old order of things. The packers advertise that their meats are "U. S. Government Inspected." Insurance companies doing business subject to the laws of such states as Massachusetts, Connecticut, New York and Wisconsin, proclaim the fact. The national banks find the supervision to which they are subjected a valuable asset. The investor's attention is called to the fact that an issue of securities has been approved by a public utility commission. Publicity of corporate accounts has proven a good thing for railway and other corporations. Factory managers now and then face about and approve regulations which they have opposed.[15] It often happens, also, that the arch insurgent of to-day is looked upon as the cautious-going conservative of to-morrow. The south no longer regards Lincoln as an enemy, but as a friend, and among the possibilities of the future is the spectacle of the business interests rallying around a La Follette as their defender against some form of radical-going socialism.

The need of distinguishing between the symptoms and the causes of political unrest is well illustrated by the silver agitation. No political movement since 1870 excited such bitter controversy or did so much to unsettle business. It undoubtedly occasioned the panic of 1893, and prolonged the hard times which followed. The legislation of 1878 and 1890 made our monetary system topheavy and rendered the continuance of the

15 Hutchins and Harrison, "A History of Factory Legislation," second edition, p. 155.

gold standard doubtful. The principal cause of the panic, however, was *the appreciation of gold*. The persistent fall of prices increased the burden of debts and imposed an unmerited hardship upon large numbers of producers. The free coinage of silver was demanded as a measure of relief. The remarkable increase in the world's output of gold relieved the country from the menace of the silver movement. If prices had continued downward, if wheat had fallen to twenty-five cents per bushel, as Mr. Bryan wrongly predicted, the silver agitation would probably have continued unabated. Likewise, the discontent due to the present era of rising prices promises to continue until the cause is removed, or until the depreciation of gold is offset by some monetary device. Economists are at present discussing the practicability of a "compensating dollar."

Too much is made of the extent to which industry is occasionally disturbed by proposed reforms. Human nature is prone to make a scapegoat of others for failures which belong at home, and this tendency seldom appears in a poorer light than when some man of large affairs blames a leading politician for results due to his own cupidity, lack of judgment or dishonesty. If political discussion did not arouse the unwary and keep the investing public on its guard, there is no telling to what lengths the issue of fraudulent prospectuses, the excessive capitalization of good will, the merging of properties at fictitious valuations and other methods of high finance would be carried. Neither is it possible to foresee how much mutual confidence and good faith would be undermined and business disturbed if the politician did not stay the use of these methods. The ordinary man often owes the politician a vote of thanks for saving him from the wiles of the manipulator of securities. The dishonest promotor is less in the public eye than the dishonest politician and is therefore more of a menace to the community. The security market needs more, rather than less, political airing. There is too much parrot-like imitation in making investments, too strong a disposition to accept off-hand opinions as authoritative, too little proneness to analyze reports and to form independent judgments. The result is that the only dollar many people feel sure of is the one they have spent. A leading Chicago daily remarks editorially:

> Neither legislatures nor state commissions are responsible for the troubles of the New Haven system. Yet those who have complained and demanded investigation have been denounced as enemies of railroads and their security holders. What would happen if we had a vast twilight zone in the railroad world; what speculators, would-be monopolists, experts in the art of running railroads from Wall street would do in that zone may be left to the imagination of intelligent men.[16]

Modern industry is so organized that it alternates between excessive activity and stagnation, and if it were possible to divorce business from politics there is little reason to suppose that trade fluctuations would be less marked. On the contrary, the reverse would probably prove true.

[16] *The Record-Herald*, July 10, 1913.

One of the most salutary uses of political agitation is, by sounding a note of caution, to keep business from running to that excess from which it is sure to rebound. Even agitation that is purely destructive may serve this purpose, however harmful it may be in other ways. The complete cessation of political agitation among a people so self-confident as those of the United States would in all probability result in such a reign of speculative activity as to prove a calamity. The politician helps to keep the industrial ship from becoming topheavy.

The fact that political agitation brings out the social side of modern life goes far to compensate for any unwarranted interference by agitators with business affairs. The various facilities, such as schools, books and magazines, which quicken the popular intelligence, would exist to little purpose if the ethical relations in which the age is so rich were barred from discussion. But for politics, considerations of public policy and the equity of social and industrial relations would receive all too scant attention. Few things bring out better the fact that we are all members one of another, or do more to turn people aside from sordid and purely personal ends. There is no game in which the nation finds more delight than politics. Few matters are so frequently the subject of editorial comment or occupy more space in the newspapers and magazines.

Our recurring presidential campaigns have an educational value which the preferential primary by compelling rival candidates to make their appeals directly to the voters promises to enhance. The discussion of such questions as free silver, the tariff, conservation, and the regulation of trusts and railways stimulates the popular intelligence. Viewed simply as a schoolmaster, Mr. Bryan has for years rendered the country an invaluable service. The wisdom of electing state officers and both houses of a legislature every year, as in Massachusetts, is more than doubtful. It is a fair question, however, whether the gain in having our presidential elections come every six years in place of quadrennially is worth what would be lost educationally. The discussion of national issues helps to preserve our sense of nationality. The primary purpose of democracy is not that men may become rich, but that human nature may be perfected by discussion, deliberation and criticism, by exercising the power of self-control, and by learning to give due weight to the rights of others. Any civilization is to be judged by the way it reacts upon the moral and spiritual side of man, and not by the extent to which it heaps up riches, however necessary the latter may be to human wellbeing and progress.

## III

In politics, as elsewhere, discretion is sometimes the better part of valor. The protected interests have mainly themselves to thank for the reduction of the tariff which they have experienced at the hands of the

Wilson administration. If they had acquiesced in a moderate reduction of duties in 1909, it is probable that they would have been spared the heavier reduction in 1913. If they had permitted the Payne bill to pass the Senate substantially as it passed the House, in place of amending it until it is doubtful whether it revised the tariff upward or downward, the country would probably have accepted the measure as a satisfactory settlement of the question. By overreaching themselves they incensed public opinion and invited a more thoroughgoing reduction of duties.

Among the arguments against protection is that it inevitably makes business the football of politics. When the tariff is under discussion, business usually slows down until the outcome is foreseen. The average tariff has a short life. Moreover, discussion that does not end in legislation often disturbs business as much as that which does. As a consequence, the protected industries seldom enjoy a long respite from the uncertainty which the discussion of the tariff necessarily entails. The history of the tariff since the Civil War, however, indicates that in the end the protected interests have usually come out on top. After the war, the internal revenue duties on many commodities of domestic production were either reduced or abolished without any corresponding reduction in the import duties. In other words, the margin of protection was substantially increased. The attempt to reduce duties in 1867 was unsuccessful. The reduction of ten per cent. in duties in 1872 was repealed in 1875. The act of 1883 lowered some duties and raised others, but it left the protective system substantially intact. Mr. Cleveland's famous message in 1887 urging a reduction of duties ended in the McKinley act raising duties to a new high level. The democratic tariff of 1894 reduced duties so slightly that Mr. Cleveland refused to sign it. In 1897, the McKinley duties were practically restored, and it is doubtful whether the act of 1909 made any reduction in the average level of duties that served a protective purpose. During all these years, moreover, besides the ad valorem duties that were avowedly protective, an additional amount of protection was concealed in specific duties that purported merely to compensate for the tariff on raw materials. As parliamentarians and political strategists, the protected interests have been more resourceful than their adversaries. The alliances between wool growers, woolen manufacturers and other interests have repeatedly carried the day. The tariff of 1913 marks practically the first discomfiture the advocates of protection have suffered since 1860.

But perhaps the discomfiture is more apparent than real. Taking the country over, the business interests have shown little concern over the reduction of duties. There has been less alarm than preceding the tariff of 1894. With the exception of a few industries, the volume of business has continued at a high level. The net earnings of many industries and of some railways have increased. Apparently, a high tariff is no longer regarded as so vital a matter as twenty years ago. In many instances, only the duties that were nominally protective have been removed by the act of 1913. Two noteworthy exceptions are wool and sugar which go on the free list, the latter, however, not till May 1, 1916. The duties on silks were probably left well above the maximum revenue yielding point. There is no reason to suppose that barbed wire will sell for less because it has been placed on the free list. The new tariff will probably reduce the cost of living but little for the average family. The by-elections, thus far, indicate a vote of confidence in the administration. Moreover, the division of the opposition into Republicans and Progressives promises to give the new tariff a fair trial. It may turn out that the popular mind has exaggerated the importance of the tariff. Many have attributed the panic of 1893 to the tariff of the following year. The part played by the appreciation of gold, the silver agitation and the reckless expansions of railroads during the eighties has been frequently ignored. It has been common to explain good times in terms of a high tariff and hard times in terms of a low tariff. The building of railways has done far more for our industrial development than the tariff, and yet it is usually treated as a matter of minor importance in popular discussion. There is at least a chance that the country will revise its theory of prosperity. Certainly, an industrial policy that promotes the growth of cities is less needed than fifty years ago. The panic of 1907 helped to shatter the popular belief that a high tariff insures prosperity. Much will depend upon the character of the times during the next three or four years. If times are good, the lower duties will probably receive undue credit. If times are hard, an undue amount of blame will probably be laid at the door of the new tariff.

## IV

The public mind is at present very suspicious of lobbyists. President Wilson recently promoted the progress of the tariff by calling attention to the number of lobbyists in Washington. The right of every one to present any facts, either in person or by proxy, to the members of our legislative bodies is generally conceded. The special interest is entitled to a hearing as well as the disinterested philanthropist. The protected manufacturer has the same right to be heard as the opponent of child labor. If the presentation is done in the open, and if the arguments employed are addressed to the minds and not to the pockets of our legislators and are unaccompanied with threats, no exception can well be taken. The average member of our legislative bodies, as well as the general public, can be trusted to make due allowance for anything one may say in behalf of his own interests. On the other hand, when those who present the facts possess the ballot, there is a fair chance that what they say will receive due consideration.

Why, then, are lobbyists regarded with such suspicion? The answer is that legislative agents have not contented themselves with presentations of facts. They have brought improper influences to bear upon our legislative and executive officers. Perhaps the extent of such influences is exaggerated. The press is prone to chronicle the evil rather than the good that men do. Exceptional instances of wrongdoing may be mistaken for the rule rather than the exception. Lobbyists are, however, rightly regarded with suspicion. The sugar trust long since earned for itself a notorious reputation. In truly non-partisan fashion, it has helped out the campaign funds of Democrats and Republicans alike and has placed both parties under obligations to look after its interests. Its rebating, custom house frauds and secret tapping of the New York City water supply have added to its notoriety. Not many years ago a street railway magnate was reputed to own the city government of Chicago in much the same sense that a merchant owns his stock of goods. "The only reason we do not have a parcels post is the four express companies," John Wanamaker is said to have remarked, when Postmaster-General. The legislatures of certain states have occasionally been the adjuncts of railway or other corporations. The investigation of the insurance companies by the Armstrong committee, whose labors Mr. Hughes so ably directed, disclosed a startling condition of affairs. The venal legislator who introduces "strike bills" has intensified the general sense of suspicion. The excessive multiplication of briefless lawyers who find it difficult to make a living has doubtless contributed to this condition. Organized labor in common with organized capital has violated the proprieties of life. When a vote affecting the employees of the Boston Elevated was taken during the last session of the Massachusetts legislature, the employees in their uniforms, present in large numbers, made such a demonstration as to intimidate certain legislators. The insidious control of certain members of the press for sinister purposes has excited popular distrust. The newspaper dependent upon legal advertisements or upon any special interest for support is to that extent compromised as an organ of public opinion.

The indiscreet friends of a cause are frequently its worst foes. This is true of protection. There are arguments of weight which can be advanced in favor of a protective tariff. The young industry argument is entitled to respect. It may be wise to diversify industries even at considerable economic sacrifice. Self-preservation requires a nation to produce at least part of its military supplies. Not least among the advantages of protection have been its political consequences. By centering attention upon Washington, and by rendering the different portions of the country industrially interdependent, it has contributed to our unity as a people. Unfortunately, however, such considerations have frequently exercised little influence in the enactment of tariffs. Logrolling has repeatedly extended protection to industries to which it should never have been accorded. Many industries have claimed protection solely as vested interests. Undoubtedly, when protection has once been applied to an industry, it should not be abruptly withdrawn. This is hardly a reason, however, for according protection in the first instance. When tariff bills have been under consideration, Washington has been literally besieged by lobbyists. Private ends rather than consideration for the public welfare lead men to overcrowd the hotel accommodations of the capitol. Presumably the expectations of selfish interests have in a measure been realized or they would long since have ceased to flock to Washington. Even the most ardent believer in "the economic harmonies" will hardly maintain that such a condition is consistent with the public weal. It is commonly believed that "campaign contributions" have been the price of a generous measure of protection. "Jokers" have found their way into tariff acts with alarming frequency. It is not surprising, therefore, that protection has suffered a partial eclipse. In fact, the most serious objection to protection is that it undermines the tone of public life. To meet this objection, its more discreet advocates have from time to time favored a tariff commission. A tariff commission has also been favored by some with a view to postponing or moderating a drastic cut in duties. The arguments which have done most to uphold protection have been in the main those of doubtful validity. The arguments entitled to respect have had little to do with its popularity. In spite of the frequency of tariff discussions, there are few subjects on which there is more loose thinking.

Three things have made the lobbyist a special menace to our public life. The first is government by committees which, according to James Bryce, "gives facilities for the exercise of underhand and even corrupt influence."[17] The second is the spirit of ultra-individualism which places private above public ends. The third is the insatiable desire to amass great wealth and to enjoy the material comforts of life. Great wealth has frequently been the stepping stone to social and political preferment. To ape the well-to-do in the exterior signs of comfort is with many a ruling passion. Happily, however, a reaction is well under way. The misuse of wealth has brought men of large means under suspicion. A large fortune has become a doubtful asset to a man seeking political advancement. The rising tide of idealism is saving us from moral degradation. The unscrupulous business man, labor leader and politician have antagonized the conscience and have aroused the public spirit of a nation. There is a stronger demand for moral earnestness in the public servant. The sins of the insurance companies helped to make Mr. Hughes governor of New York.

(*To be continued.*)

[17] "The American Commonwealth," edition of 1910, Vol. 1, p. 162.

DR. E. B. WILSON. DR. E. C. PICKERING.

Photograph taken at Atlanta of the president of the American Association, Dr. E. B. Wilson, professor of zoology, Columbia University, and of the retiring president, Dr. E. C. Pickering, director of the Harvard College Observatory.

# THE PROGRESS OF SCIENCE

## *THE ATLANTA MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE*

THE meeting at Atlanta was unusually pleasant for those who were able to be there. This is likely to be the case when the association meets at a distance from the larger scientific centers, for both the trip and the place are interesting and the welcome is cordial. Thus, for example, the name of the governor of the state is often on the program of the opening meeting, but he usually finds himself unable to be present on account of official business, whereas at Atlanta the governor and Mrs. Slaton gave a reception to the members at their home. At smaller meetings of the association, such as those at Denver, New Orleans and Atlanta, the members are not only likely to see more of their local hosts, but also to be more intimately thrown together outside the rooms of their meetings.

As a matter of fact the meeting at

DR. FRANK SCHLESINGER,
Vice-president for Mathematics and Astronomy, director of the Allegheny Observatory.

Dr. Alfred D. Cole,
Vice-president of the Section for Physics, professor of physics in Ohio State University.

Atlanta was of fair size. There were on the program 428 papers, distributed as follows:

| | |
|---|---|
| Mathematics and astronomy | 30 |
| Physics | 20 |
| Chemistry | 16 |
| Engineering | 31 |
| Geology | 34 |
| Zoology and Entomology | 111 |
| Botany and Phytopathology | 108 |
| Anthropology, Psychology and Education | 36 |
| Economics and Social Science | 29 |
| Physiology and Experimental Medicine | 13 |
| | 428 |

As the national societies for botany and entomology met at Atlanta these sciences were well represented. Most of the national scientific societies held their meetings in the north, while the chemists now meet in the autumn. But it will be noted that each of the sciences had an adequate representation.

In addition to the technical papers containing accounts of research work, there were many addresses and several sessions of general interest, intended not for the specialist, but for those scientific men who care to know what is being accomplished in sciences other than their own and for the general public. The address of the president of the association, Dr. E. C. Pickering, director of the Harvard College Observatory, recounted the progress of the study of the stars, in which he and the observatory which he directs have had such an important share. The addresses of the vice-presidents for the sections were as follows:

Mathematics and Astronomy: "The Influence of Fourier's Series upon the

Development of Mathematics,'' by Edward B. Van Vleck, the University of Wisconsin.

Physics: ''The Methods of Science: To What do they Apply?'' by Arthur G. Webster, Clark University.

Mechanical Science and Engineering: ''Safety and the Prevention of Waste in Mining and Metallurgical Operations,'' by J. A. Holmes, U. S. Bureau of Mines.

Geology and Geography: ''Pleistocene History of Missouri River,'' by J. E. Todd, the University of Kansas.

Zoology: ''The Story of Human Lineage,'' by William A. Locy, Northwestern University.

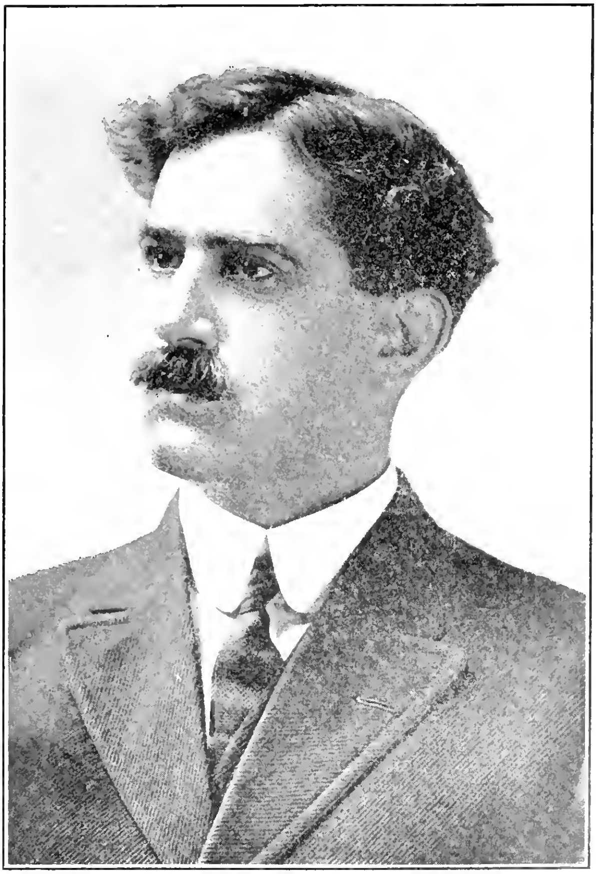
Botany: ''The Evolution of a Botanical Problem,'' by Duncan S. Johnson, The Johns Hopkins University.

Social and Economic Science: ''The Development of our Foreign Trade,'' by John Hays Hammond, New York City.

Physiology and Experimental Medicine: ''The Physiological Instruction of Medical Students,'' by J. J. R. Macleod, Western Reserve University.

Education: ''Science, Education and Democracy,'' by J. McKeen Cattell, Columbia University.

There were also given two public lectures complimentary to the citizens of Atlanta, one by Dr. Ch. Wardell Stiles,



DR. C. L. ALSBERG.
Vice-president for the Section of Chemistry, Chief of the Bureau of Chemistry, U. S. Department of Agriculture.


Dr. O. P. Hood,
Vice-president for the Section of Mechanical Science and Engineering, U. S. Bureau of Mines.

of the U. S. Public Health Service, on "The Health of the Mother in the South," and one by Professor Chas. E. Munroe, of the George Washington University on "The Explosive Resources of the Confederacy during the War and Now: A Chapter in Chemical History," each admirably adapted in subject matter and treatment to the occasion. The sections of the association do not have programs of technical papers when the ground is covered by a society meeting in affiliation with it. In that case programs of general interest are arranged by each section. The American Association is thus in respect to the research work of the special sciences essentially an affiliation of societies rather than of individuals, but it retains the important functions of keeping the sciences in touch with each other and representing science before the general public.

The Monthly is conservative in printing portraits of living men of science, but it aims to reproduce once a year the photographs of the president and vice-presidents of the association, as it seems desirable for as large a number as may be to become acquainted to this slight extent with those most actively engaged in advancing science in America. The officers elected at Atlanta continue the high traditions of the association. The section of education, not hitherto represented in the presidency, was able to provide a president of great distinction, Dr. Charles W. Eliot, emeritus president of Harvard University, once professor of chemistry, for more than forty years our leader in education.

### *THE WORK OF THE COUNCIL OF THE ASSOCIATION*

The council of the American Association is the body in this country best organized to advance the interests of science. It includes the past presidents of the association, who give a certain stability and dignity, but is otherwise an elected body, representing directly or indirectly the different sections of the association and the national scientific societies. Each affiliated society, of which there are some thirty, is represented in the council, which thus becomes a body representing the eight thousand members of the association and practically every scientific man of the country.

The National Academy of Sciences is by law the scientific adviser of the government, but, as is shown in the recently published volume commemorating its fiftieth anniversary, the advice of the academy has been asked only once in the past ten years, and the report was pigeon-holed. The fact is that the vast increase of the scientific work

Dr. J. S. Diller,
Vice-president of the Section for Geology and Geography, geologist, U. S. Geological Survey.

DR. HENRY C. COWLES.
Vice-president for the Section of Botany, professor of botany in the University of Chicago.

under the government provides it with scientific men in its employ competent to give advice, and the constitution and traditions of an academy composed of a small number of life members selected for distinction in research do not lead to great activity or efficiency. Thus several years ago a resolution endorsing the use of the metric system was defeated on the ground that the advice of the academy had not been asked.

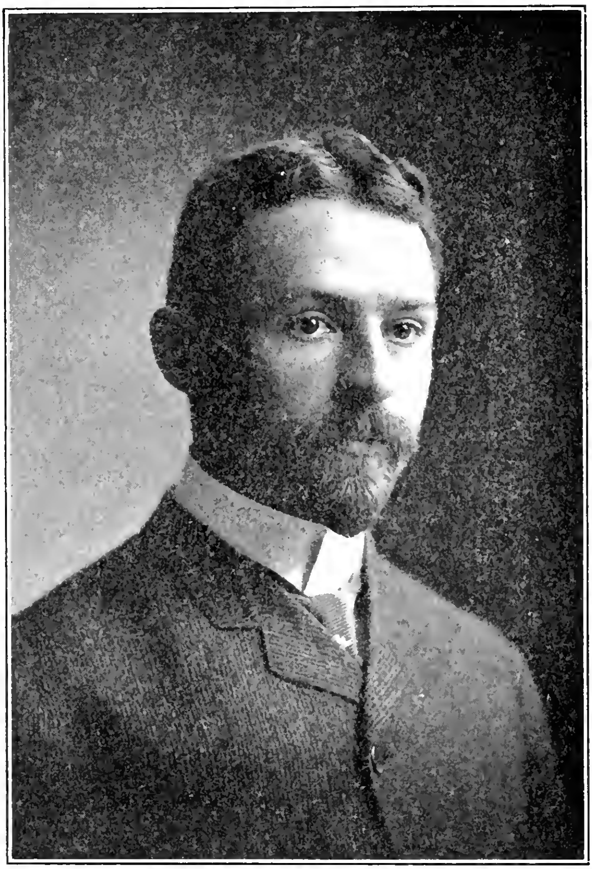
The council of the American Association being an elected body representing all the scientific men and scientific activities of the country is in a better position to assume active leadership in movements for the advancement of science and the applications of science for the public welfare. Several such actions taken during the past years may be noted. At the spring meeting of the council a committee was appointed to confer with the president of the United States in regard to the heads of the scientific bureaus of the government and especially the chief of the Weather Bureau. The president received the committee courteously and the secretary of agriculture held a conference with the committee on policy of the association. This committee made subsequently certain recommendations in regard to the qualifications of heads of the scientific bureaus of the government and recommended that the National Academy of Sciences be requested to appoint an official committee to advise the secretary of agriculture in regard to the chief of the Weather Bureau. This was done and the secretary of agriculture appointed Dr. Marvin, one of the three men endorsed by the committee of the academy. The secretary of agriculture would probably have made the same appointment without official scientific advice, though it is evident that this is a valuable safeguard.

Another instance of the usefulness of the council of the association is the committee on expert testimony appointed last year which made a preliminary report at Atlanta through Dr. E. C. Pickering and Dr. W. H. Holmes. The committee includes members of the association so eminent in their subjects as Dr. W. H. Welch in medicine, and Senator Elihu Root in law. It is a matter of public notoriety that the present methods of expert testimony in courts often defeat the ends of justice and bring science into disrepute. It is fortunate that we have a body so well fitted to attempt the reform of this procedure as the American Association.

The third action of the council which may be noted is the appointment of a committee of one hundred in research. Two sub-committees have already been organized, one to report on the existing research funds of the country and possible means of cooperation to increase their usefulness, the other on research in educational institutions which will make inquiries as to the extent to which research work by professors and instructors is encouraged in colleges and universities.

At Atlanta there were also adopted several plans looking to the increased

DR. THEODORE HOUGH,
Vice-president for Physiology, professor of physiology, University of Virginia.



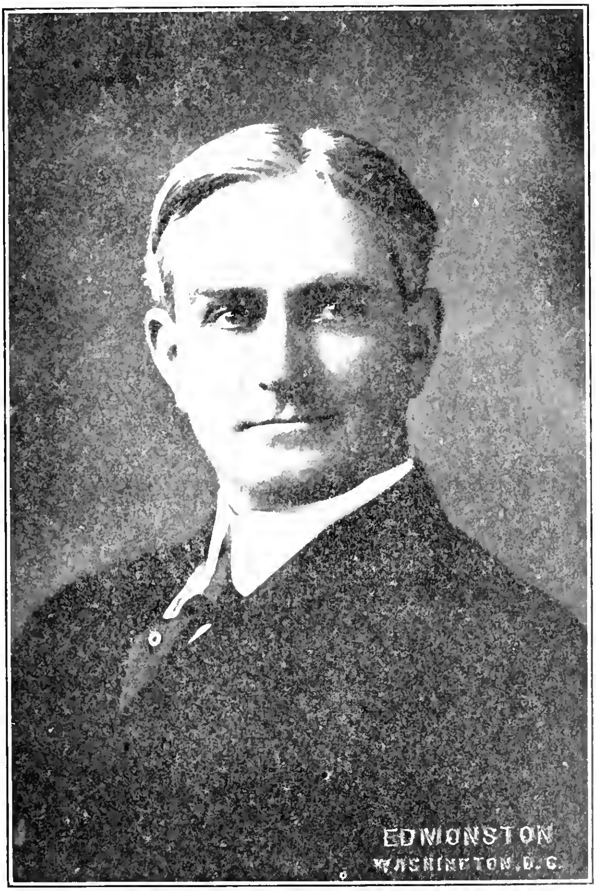
Dr. W. B. Pillsbury.
Vice-president for Anthropology and Psychology, professor of psychology, University of Michigan.

usefulness of the association. Reports were received in regard to the organization of the Pacific Coast Division, authorized a year ago, in view of the meeting of the association in California at the time of the Panama Exposition, but also empowered to hold independent meetings. The associate secretary for the south made a report on conditions in that region. A committee with Senor Eduardo Braga as chairman was formed with a view to the organization of a Brazilian division. If the association can become "American" in fact as well as in name, it will be a stimulus to science throughout the western hemisphere and a means of promoting good-will among its republics. The establishment of local branches of the association was authorized in places where the members are prepared to conduct branches which will forward the objects of the association. This movement has possibilities of great development, especially in institutions and places somewhat remote from the large scientific centers where there are no academies of sciences or similar organizations. It was decided to arrange once in four years—in New York in 1916–17 and in Chicago in 1920–1—representative convocation-week meetings, in which it is hoped that all the affiliated societies will unite so that the men of science of the whole country may be brought together and the importance and magnitude of their scientific work may serve as a stimulus to them and an impressive lesson to the general public.

### *THE ADDRESS OF THE PRESIDENT*

In his presidential address before the association Professor Pickering stated that American universities and colleges devoted a hundred times as much time and money to diffusing human knowledge as to the object of the American Association of Science. The greatest need of science at the present time is the means for aiding the real men of genius.

The first catalogue of the stars was made by Hipparchus two thousand years ago. A thousand years later it was revised by a Persian astronomer Sûfi. They show not only that the positions and brightness of the stars have changed but little in two thousand years, but that the same may be said of the sensitiveness of the human eye to lights of different colors. The places of the stars were first accurately deter-




DR. P. P. CLAXTON,
Vice-president for Education, U. S. Commissioner of Education.

mined a century and a half ago, but the chronograph, known for many years as the American method, is only half a century old.

One of the greatest astronomical researches has been the measurement of the exact positions of 166,000 stars. The sky was divided into twenty zones of which seven were taken by Germany, four by the United States and three by Russia. Of the American zones two were observed at Cambridge, one at Albany, and one at Washington. Each occupied the time of several astronomers for twenty years. It is now nearly time, after fifty years, to reobserve these stars to determine their motions. Fortunately, two new methods, the transit micrometer and photography, have been found which will greatly reduce the labor. The older department of astronomy, measuring the positions of the stars, has been left in America to the Naval Observatory. Unfortunately, the law requires that the superintendent must be a naval officer who can not remain long on land. The average term of office is less than two years. The average term at Greenwich is thirty years, where with but half the income, more than double the work is done. Congress, though repeatedly appealed to, will not remedy this great waste of the public funds.

Two million measures of the light of 80,000 stars have been made at Harvard. The results have been accepted by an international committee as the standard for the world. Such measures are likely in the future to be replaced by photographs taken with yellow light. A certain class of stars vary in brightness. Some increase in light many thousand times, others double their brightness in seven minutes with perfect regularity. Many thousand excellent observations of these objects are now obtained every year by amateurs having only small telescopes. Nearly five thousand variable stars are known of which three quarters have been found at Harvard. Astronomical photography, and American invention, replaces eye observations in almost all researches. Two Harvard telescopes have each taken 40,000 photographs whose combined weight is about forty tons. They give the only record on the earth of the history of the stars for the last quarter of a century. Photographs of the spectra of the stars to determine their motions form the principal work of the Lick, Yerkes, Greenwich, Potsdam and many other of the larger observatories. A catalogue of the spectra of 200,000 stars is now being compiled at Harvard, and will fill seven large quarto volumes.

The friendly cooperation of American astronomers has greatly advanced the work in this country, but it will be difficult to compete with the splendid observatories and instruments now lavishly furnished in Germany. If similar support is given us, the American Association for the Advancement of Science can fulfill its objects as regards astronomy.

## *SCIENTIFIC ITEMS*

Science in America has during the past month lost three of its most distinguished leaders—Dr. S. Weir Mitchell, the eminent physician, physiologist and man of letters, of Philadelphia; Dr Seth C. Chandler, the astronomer of Cambridge, and Dr. Benjamin Osgood Peirce, Hollis professor of mathematics and natural philosophy at Harvard University.

Dr. Charles Budd Robinson, economic botanist of the Bureau of Science of the Philippine Islands has been killed by natives in the Amboyna Islands in the Malay Archipelago.

It is proposed to place a suitable memorial of the late Alfred Russel Wallace in Westminster Abbey. It is also proposed to present a statue or bust to the British Museum of Natural History and a portrait to the Royal Society. Contributions to the Alfred Russel Wallace Memorial Fund may be sent to the London and Smith Bank, Holborn Circus, London, E.C.

# THE POPULAR SCIENCE MONTHLY

MARCH, 1914


## ON THE ORIGIN OF THE FLOCKING HABIT OF MIGRATORY BIRDS


BY PROFESSOR C. C. TROWBRIDGE

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IT is a noteworthy fact that many species of birds which take long migratory journeys make these movements in large flocks. The same is true to a less extent of the species which makes long daily flights for food. The origin of this flocking habit is not completely explained by the three ordinary theories, which neglect two most important considerations. These theories attribute the formation of the flock to the companionship which it affords, to the experience of old birds that know the sign posts of the journeys and hence lead the way, and to that protection against enemies, which may be secured by numerical strength; but two other protective features, of prime significance, are here overlooked. In the first place, the large flock automatically, by its numbers, maintains the proper direction of migration; secondly, and just as automatically, in the case of many large birds, the flock is warned and protected against its enemies by its form, or arrangement. The importance of these two automatic methods of protection is readily brought out by a consideration of the influences which tend to deviate the flock from its true course, on the one hand, and by a study of the actual groupings of birds in migratory flocks on the other.

### AUTOMATIC PROTECTION OF A LARGE FLOCK

The chief causes of errors relative to direction of flight to which a single migrating bird is subject, are:

(*a*) *Confusion* with respect to the proper direction of flight.
(*b*) Effect of heavy winds or thick fogs acting as a temporary confusing factor while a flock is migrating.
(*c*) Gradual deviation from the proper course due to unequal wing power.

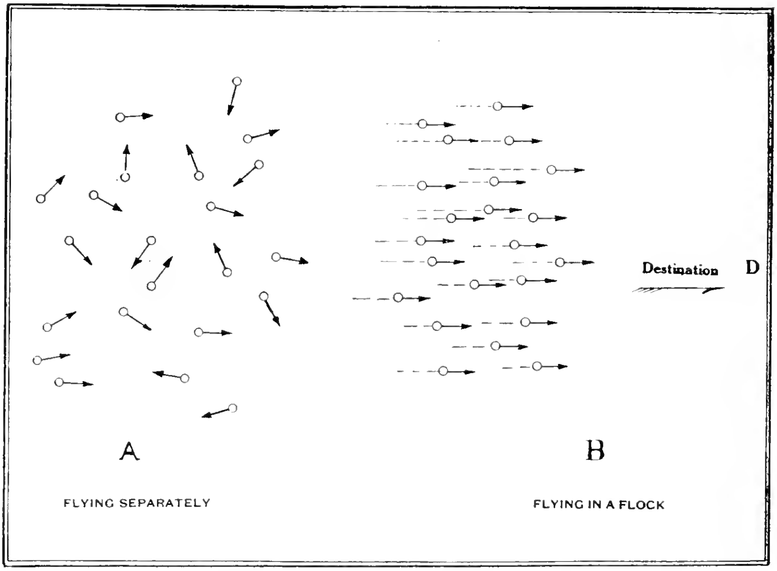


FIG. 1. In the left-hand diagram, *A*, the arrows are intended to represent birds and the directions in which each individual would fly *if alone*. Thus they indicate the amount of confusion of each bird with respect to the true destination *D*. In the right-hand diagram *B*, the birds are represented flying *in a flock*, the errors of orientation having been *averaged* by mutual reaction as indicated by the parallel arrows.

The large flock seems to eliminate these causes of error to a considerable extent, therefore it is probable that the origin of the flocking custom is largely due to the fact that it is protective.

The explanation suggested by the author to account for the flocking habit is as follows:

### The Direction Errors of the Individuals of the Flock are Averaged

If, for example, in the case of a migrating flock, there are any individuals that are confused in their bearings with respect to the direction of their destination, and there must be many that are more or less confused, some erring toward the right, some toward the left, the errors of the individuals of the flock are *automatically averaged and corrected by imitation, and by mutual reaction by those same individuals.*

According to this hypothesis, birds flying in a flock will follow the direction which may be called the mean flight direction of the flock. The idea is illustrated by a diagram. In Fig. 1, *A*, *the arrows* attached to circles are meant to represent the directions that the individual birds of a migrating flock would take, for example, after resting on an open sea, and arising to fly to an intended destination, *D*, (Fig.), provided *each individual was required to migrate alone from that moment.* The assumption is made that most of the birds are confused with respect to the correct orientation to a greater or less extent, which is obviously the fact, although the confusion may be very slight in some cases. In Fig. 1, *B,* the direction in which the birds will actually move *when in flight as a flock* is indicated by the parallel arrows. Thus in Fig. 1, *B,* the mutually related influence of the individuals prevents the dispersion that would occur as indicated by the direction of the arrows in Fig. 1, *A*. The averaging of the errors that take place, as indicated in *B,* is approximately governed by mathematical certainty, and as a matter of fact, in the drawing Fig. 1, *B,* the flight direction was determined by taking the mean of all the directions indicated by the arrows in "*A*."

Each bird is affected by the averaging of flight directions due to the mutual reaction of the individuals, and the reaction prevents false starts. As an extreme case of this correcting influence, consider a flock of birds proceeding northward after resting on an open sea in a fog; and suppose that one bird was so confused that it would have flown in the opposite direction (to the south) *if alone.* Then, in all probability, in spite of its individual inclination to fly south, this bird would be carried northward with the flock by the powerful principle of imitation.

It must be distinctly understood that this theory does not give an explanation of the sense of direction, but it does provide a mechanism which will prevent individuals of the flock from getting lost. The only assumption is that there are all degrees of right and wrong "bearings" among the individual birds of the flock.

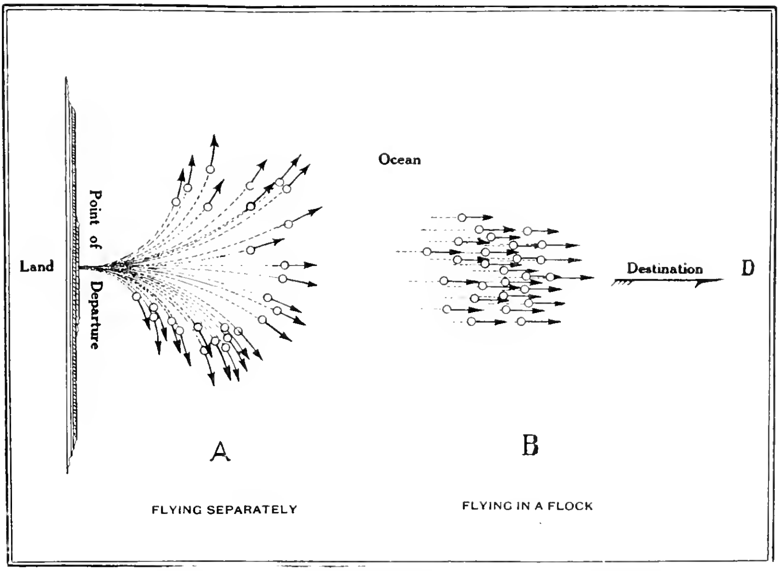


FIG. 2. The curved lines in the left-hand diagram *A* represent the paths which the birds would follow due to unequal unbalanced wing power, *if each was alone.* In the right-hand diagram, *B,* the arrows represent the birds *flying together* and the direction is the *mean* of all deviations and represents the flight direction towards *D* as corrected by mutual reaction.

FIG. 3. PLATOON FLOCK FORMATION, which is seldom observed; only the end birds can see towards the side. The field of view becomes *more obscured* as the number of birds *increase*. Non-protective.

The influence of every bird in the flock will affect the flight direction of the flying flock to some extent, yet they each produce their reaction, although perhaps not proportionately. It is probable that the birds in the front of the main part of the flock affect the direction greatest.

## AVERAGING OF THE ERRORS OF FLIGHT DUE TO UNEQUAL WING POWER OF BIRDS

It is a well-known fact that when man is lost on a prairie or in a snowstorm he will often travel in a circle. The reason for this is that there is a *small constant deviation* of his course to the right or to the left. Small as this deviation may be, it is certain to throw him completely off his bearings, and not infrequently results in circling with fatal results. It is possible that a bird is subject to a similar deviation of its course, owing to the inevitable production of a *curved flight path* in case *one wing* of the bird is stronger than the other, the effect being similar to a man in a boat pulling at the right oar more powerfully than the left. Now the error of individual birds caused by a constant deviation of path due to unequal wing power, as well as the error due to mistaken "bearings," would be corrected if the errors of the individual birds in the flock are averaged while in flight by mutual reaction. Fig. 2, *A*, is meant to illustrate these deviations due to unequal wing strength, or to some similar cause, when single birds are proceeding, for example, from the mainland to a far distant island destination *D* (Fig. 2), and Fig. 2, *B*, the result when the birds are flying in a flock and when these deviations are averaged. It is of course evident that the averaged deviations might give a flight direction that is not exactly the right one, and a flock of birds might fly in a wrong direction if much confused. This is exactly what takes place: for occasionally flocks of geese and other species of birds have been known to become completely confused in a fog or during a stormy night. It is a very common occurrence for birds that are alone to become lost, as shown by the fact that so frequently single land birds alight, utterly confused, on vessels far out at sea.

The averaging of the errors of the direction of flight of the individuals is of course subconsciously done by birds and is quite automatic.

The principle of mutual reaction and its advantageous effect may be advanced as a reason for the massing of birds into flocks prior to the migratory journey, for if it is true that the flock formation has proved helpful in migration, it is to be expected that the flocking together for the migration has slowly developed into a well-formed habit. Of course the desire for companionship and also the following of a leader must be additional reasons for the flocking of birds, but taken together or alone they do not seem to be a complete explanation.

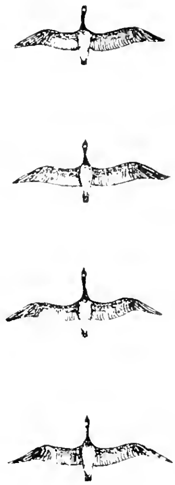

Fig. 4. Single-file Flock Formation, which is seldom observed. Only the first one or two in the line can see ahead. The field of view becomes *more obscured* as the number of birds *increase*. Non-protective.

### The Night Migratory Call of Birds

During the spring and autumn migrations at any time during the night in regions traversed by large and small wild fowl one can hear the curious night call of the passing birds. This call is generally regarded by ornithologists as a signal by which the birds may communicate from one to another. The night call, in the case of many species, is apparently only used while migrating, as it is also apparently nearly alike for certain species, although the matter has been little investigated. There are, however, sufficient reasons for the belief that the call has a special purpose, and that it may be a protective measure which aids in preventing the individual birds of small flocks from deviating from the correct migratory course. The call can be heard almost any time during the nights of April and May and also of August and September, the months when the greater number of birds make their migration in the temperate zone. The night call note appears to be different in many cases from the usual day cry of the birds and is peculiarly short and

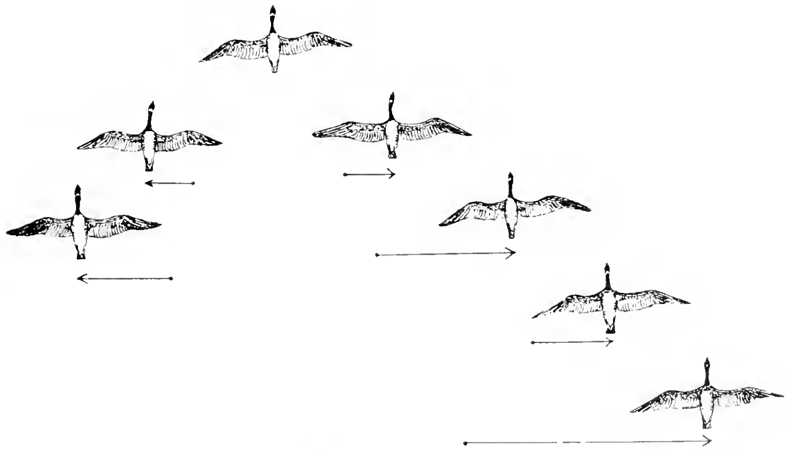

Fig. 5. Echelon Flock Formation. The usual flight formation of large birds. *All birds* can see *ahead,* and *towards one side,* making the best arrangement for protection. The protective efficiency of the formation *is little affected by an increase* in the number of birds of the flock.

sharp. If the call of any particular individual bird is listened for, it appears to be repeated almost systematically every few hundred yards as the bird travels on its journey. In the absence of some proof of the true significance of the call note, an explanation can only be a hypothetical one, but it certainly appears as if the relation in space of one bird with its neighbors would be roughly maintained by this night call. If we imagine the birds distributed here and there in the air throughout the area through which the migration is taking place, the effect is that of a great flock flying, for example, southward, the individuals of which are widely separated. Each bird repeatedly signals to its neighbors and thus learns from its fellow travelers the general direction of migration.

Of course where there are many species in migrating, the velocity of flight of the various individuals would be different, and some birds would relatively advance and others fall behind, but a movement by a single bird diagonal in direction to the main movement of the migrating birds would at once be made evident by means of the sentry-like calls of the birds, both to the straying bird itself, and to the other alert individuals taking part in the migratory movement.

The importance of the mutual reaction of individual birds, set forth in a previous paragraph, as a means of preventing deviation from the correct course of flight, may apply to the night migration of many birds which are known to migrate singly, or in small flocks. That is, the mutual reaction of the individuals and small flocks, would then be communicated by the night call rather than by imitation through sight,

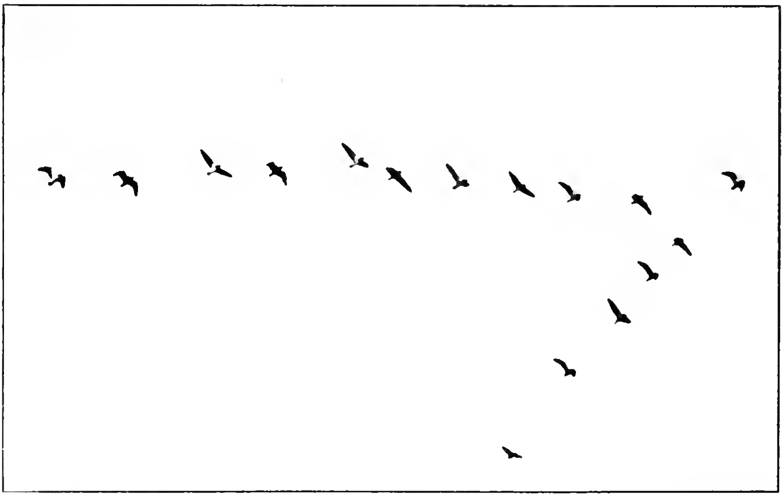

FIG. 6. FLOCK OF BLUE GEESE IN ECHELON FORMATION, photographed at the Mississippi delta by the Rev. H. K. Job. Note the acute angle of the flock and that for each goose the view is unobstructed in front and on the side.

or air pressure as in the closely formed flocks during the day. That countless numbers of birds migrate at night has been abundantly demonstrated and requires no proof.

### The Protective Form of Certain Flight Formations

The flight formations of birds which fly in flocks vary greatly with different species, so varying is it that in many cases it is an identifying characteristic. Many small land birds fly in very compact groups, examples of which are the various species of blackbirds, grackels, cedar birds, finches, etc. Many water birds fly in compact flocks. Moreover, for many species there seems to be some general law regarding the size of the bird and the distance apart of the different individuals of the flock.

### Probable Explanation of the Echelon Formation

The most distinctive formation is the echelon arrangement of flight and deserves special attention. Many of the larger water birds such as geese, many species of ducks, flamingoes, etc., practise this method of flight. The formation, according to one explanation, owes its origin to the fact that such an arrangement prevents swirls in the air produced by the wings of one bird from interfering with the next bird following. This may be true to some extent, but the explanation which the author holds as far more likely is that the formation is chiefly, if not wholly, a protective arrangement, and is, in fact, the only one in which the individual birds of the flock, if they are of considerable size, can see both forward and to the side at the same time, as demonstrated by the

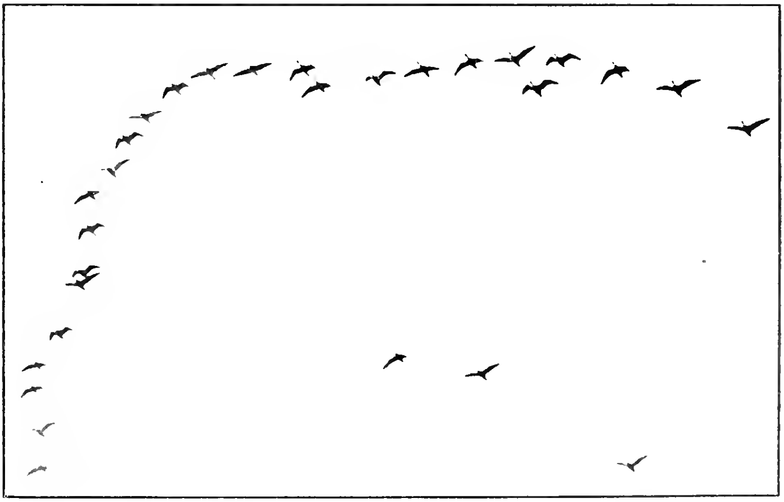

Fig. 7. Flock of Blue Geese in Echelon Formation, photographed by the Rev. H. K. Job. As in Fig. 6, for each goose, the view is unobstructed in front and at right angles to the line of flight.

illustrations, Figs. 3, 4, and 5, and also the exceptionally fine photographs, Figs. 6, 7 and 8, taken by the Rev. H. K. Job, state ornithologist of Connecticut, who kindly provided them for illustrating the present discussion.

It is probable that the echelon formation has come about partially by the fact that birds naturally follow one another by imitation. For example, suppose a flock of geese arises from a surface of water in one of

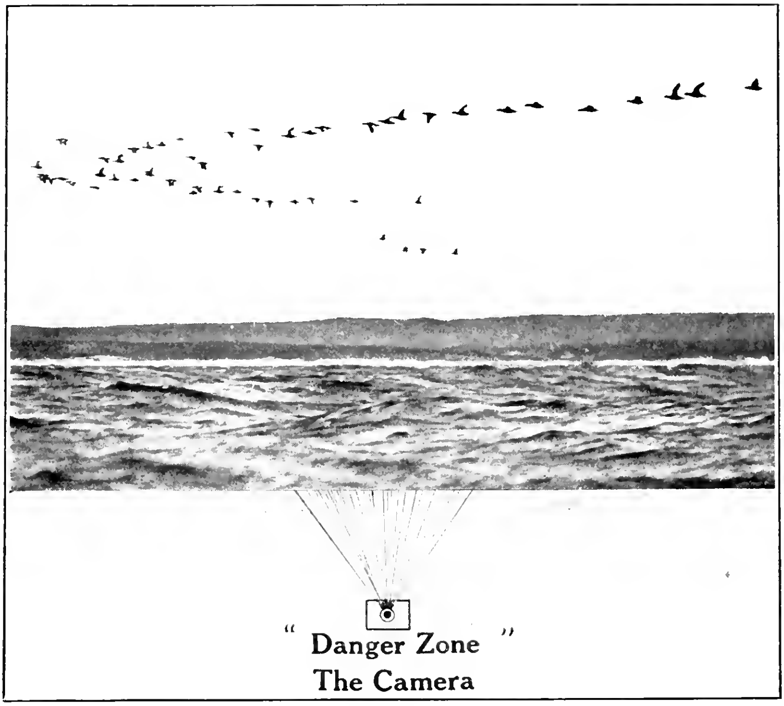


Fig. 8. Flock of White-winged Scoters in Echelon Formation, migrating off Manomet, Mass. Photographed by the Rev. H. K. Job from a row-boat. The heads of all the birds can be seen from the boat. At the moment the camera appears as the danger point to the birds. *Every eye on the boat side has an unobstructed view.*

their daily flights to their feeding ground: at first the individuals will be grouped together indiscriminately, many following those that are leading. Then, for example, the second bird in line will shift to the right or left to be able to *see ahead* as well as *to the side*, and so on down the line. While the mode of flight is now a well-formed habit, yet the process of producing the formation goes on to some extent each time a flock (of geese, etc.) begins a flight. The echelon formation is thus the one that will permit the greatest number of birds to see towards the chief danger zones, the front and the sides. Perhaps this explanation has been given by others, but the author has not found it in other writings. Small birds that pursue an irregular flight (*i. e.*, undulating or fluttering) have an opportunity to see into the danger zones even when in a large flock; hence the necessity is lacking for the echelon arrangement of the individuals of a flock in such cases.

Among certain species of ducks a reverse echelon flight formation is observed, namely, the directions of flight is in the opposite direction to the point of the V. The reverse V is nearly as protective as the V. Since in this form also the *number of eyes* of the birds in the flock which cover the "danger zone" is at a maximum. The above hypothesis does not in any way conflict with the theory that geese will follow a leader, a theory which may or may not be true.

The facts presented above are taken as strong arguments for the conclusion that the origin of the flocking habit is due to its protective effects, and that particularly the echelon arrangement of flight has been evolved from the protection against enemies which it affords.

This investigation has been aided by a grant from the Herman Fund of the New York Academy of Sciences.

# WATER

By E. P. WIGHTMAN, Ph.D.
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THALES, one of the Seven Wise Men, said:

> Water is the element, the first principle of things.

There is no doubt that Thales thought he knew a great deal about water, but even the average man to-day probably thinks he knows much more. Yet, what does he know about it?

It would be difficult to overestimate its great value to the human race, and its far-reaching importance in matters scientific.

> In its various forms it has been dealt with by some of the most eminent of scientists, and the subject, like the boundless ocean, is so wide that there are few branches of scientific research in which it does not claim attention.

First of all, what is its source? According to the astronomers and geologists, the earth is nothing more than a condensed and cooled portion of a vast nebula, which must have been similar to many now adorning the heavens. This nebula was a mass of self-luminous, gaseous matter, very highly heated. Of course, water, as such, could not exist in this, but was dissociated, or separated into its constituent parts, the two gases hydrogen and oxygen. Above a temperature of 2,000° C. or 3,632° F., these gases do not combine to form water, whereas the earth, in the molten, to say nothing of the gaseous condition, must have had a temperature hardly less than 6,000° C. However, the earth finally cooled sufficiently for the water to form as steam and then to condense to the liquid state.

For a long time, in fact until about 130 years ago, it was thought that water was an element. Aristotle named it as one of the four elements, earth, air, fire and water. This view of the composition of so-called matter held sway for several centuries. Even after the theory was broken up, water still remained as an element. It was not until 1781 that it was found to be a compound substance. Priestly, and likewise Lavosier, showed that when hydrogen is burned, water is the outcome. The ideas of the former, however, were in conformity with the phlogiston theory which held sway at that time. By the experimentation and study of later workers on this subject, this theory was overthrown and water was proved to be a combination of hydrogen and oxygen in the proportion of two parts by volume of the former to one part by volume of the latter, or by weight, 2.016 parts of the former to 16 of the latter. The proof is as follows: Known quantities of hydrogen and oxygen are exploded and the water formed is weighed or the amount of each gas used is measured. Also water is decomposed by electrolysis and the hydrogen and oxygen thus formed (the only things formed) are measured.

The heat given off in the combination of the gases is enormous, indeed, it is the most exothermic of all chemical reactions, 67,500 calories or heat units being evolved in the combination of 16 grams of oxygen with 2.016 grams of hydrogen—a calorie is that amount of heat which will raise one gram of water 1 degree centigrade. In the absence of indifferent gases, or an excess of one of the reacting gases, the reaction is not only so violent as to raise the gases to the combination temperature, 2,000° C., but to carry them beyond to 2,844° C., at which temperature only about one third of the gases combine, the remainder doing so gradually as the temperature falls. Almost any non-reactive (catalytic), highly heated substance, such as platinum sponge, or wire, stone, porcelain, glass, etc., will bring about a combination.

An oxy-hydrogen blowpipe is an arrangement for utilizing this heat energy, by bringing the two gases together in such a way that they will produce a sharp, intensely hot flame. The apparatus is so fashioned that the gases are conducted separately through the exit where they are to be lighted, thus avoiding any possibility of explosion, which otherwise takes place, if they are mixed. By means of such a flame, a temperature of 2,000° C. can be obtained.

Having learned that water (at least in the form of its components) is older than even the earth itself, that its constituent parts existed practically at the beginning of things, and also that it is not an element, but built up of two gases combined in a definite proportion, let us now take up the substance itself and study it in its various forms. These are quite numerous, but may all be classified under three fundamental heads: gaseous, liquid, and solid water.

The fact that it can exist in these three states is not so remarkable, since it is possible to transform every known substance, elementary or combined (provided the latter do not decompose) into these three states of aggregation; but that the three should all be within the range of *ordinary* temperatures *is* rather extraordinary. There are only a few common substances of which this is true, *e. g.*, ammonia, benzene, etc. It will be seen, moreover, that water has a good many other noteworthy properties. As compared with other substances it is nearly always exceptional, and stands at the extremes.

*Gaseous Water.*—Steam and atmospheric water vapor belong in this category. It is not until we go to some of the arid desert regions of our earth that we realize the importance of the latter. Where there is no moisture in the atmosphere, there can be no clouds formed, and hence there can be no rain, which means, of course, that such a place must be devoid of life; for example, the Sahara, the deserts of Asia, of western United States, etc. Yet the presence of moisture can be very disagreeable, as in hot, humid climates. The amount in the atmosphere varies considerably, depending upon the complex condition of climate and topography, therefore no general data can be given.

*Steam.*—The very word signifies the sublime, the wonderful! What could we do at present without it? How many thousands of mills, shops, locomotives, etc., derive their power from it? Power? Let us stop and consider—*1 gram of water in the form of steam occupies 1,700 times the space that a gram of water in the liquid form does.* Is it any wonder that steam is a mighty agent? If a sufficient quantity is confined and superheated, as was the case when the volcanic mountain of Krakatoa was almost completely annihilated, there is nothing that can withstand it.

According to the theory of kinetic energy, the molecules of all substances are in rapid motion, and at the surface of liquids, water in particular, there is a tendency for some of the rapidly moving particles to be thrown off into the atmosphere and to form vapor. Likewise, some of the vapor molecules pass back into the liquid again. When the tendency of each to pass into the other is exactly counterbalanced, we have what is called a state of equilibrium between the two phases. This tendency of the molecules to pass off into the atmosphere, even at lower temperatures, gives rise to a certain amount of pressure, called "vapor tension." The atmosphere, or any artificial pressure which may be applied, tends to overcome this. At every temperature only a certain amount of water vapor can exist under a given external pressure, viz., the vapor tension of water at that temperature. At that pressure you have a "saturated vapor." Stronger pressure causes liquefaction; reduced pressure, an increase of vapor.

Steam is that condition or phase of water which is stable at temperatures above 100° C., at ordinary atmospheric pressure (760 mm. mercury). At this temperature and pressure the vapor tension of the liquid water is so great that none of it can remain in the liquid state. Increased pressure tends to drive back the steam into the liquid state again, the temperature of boiling being increased directly in proportion to the temperature. Up to a certain temperature, the "critical temperature," 360° C., water can be made to remain in the liquid state by applying sufficient pressure. Above that it can exist only in the form of a gas, no matter how great the pressure. It is possible, by using a small enough quantity of water and a *sufficiently strong* apparatus, to determine the critical temperature and pressure by experiment.

The amount of heat absorbed in the transformation of a unit quantity, 1 gram, of water at 100° C., into steam, that is, its heat of vaporization, is 537 calories (this is exactly the same in amount as its heat of condensation). It is easy to see, then, why it takes so long to boil away a large quantity of water. The amount of heat absorbed which is necessary to raise the water to its boiling point and keep it there is simply enormous. It may be said here that after the water once reaches the temperature 100° C., it remains there until the whole of the liquid boils away, even though the amount of heat applied is somewhat in excess of that required to keep it at the desired temperature.

*Liquid Water.*—Very much more interesting and important than any other form of water is liquid or "wet water." In this form it is the most fascinating of all chemical substances, besides being the most useful. In the first place it forms 75 per cent. of the human body and without it *nothing* could live. It covers about two thirds of the earth's surface to an average depth of about 12,500 feet. It is the best solvent known; as will be shown later, it is an essential to almost all chemical action. Here again life as well as nearly all branches of science would be at a standstill if it did not exist. It occurs as rain, fog, dew, river and ocean water, spring water, etc.

When the vapor of the atmosphere condenses around small particles of dust in the air, clouds are formed, or, if down near the surface, a fog. Whenever these small particles run together they produce drops which fall as rain. Dew is nothing more than water which has condensed out of the atmosphere on to cold objects. Only so much moisture can be held in the air at a given temperature if this is lowered, as would happen after the sun goes down, the dew separates out. If pure, water is an odorless, tasteless and in small quantities, colorless, transparent liquid. In bulk it becomes blue in color and very nearly opaque. It never occurs *pure* in nature, the nearest approach to it being rain-water after it has rained for some time (at first the rain gathers up a large amount of impurity from the atmosphere); and melting snow. Water can be readily purified by distillation. For ordinary purposes one distillation is enough, but for certain scientific work a special method of distillation must be resorted to. In this degree of purity it is almost a non-conductor of electricity.

Water is only slightly compressible. For every atmosphere (15 pounds per square inch) of additional pressure, it is made smaller by 0.0005 of its volume. The effect of pressure upon its freezing point is also exceedingly small—only 0.00757° C. lowering for each atmosphere. Nevertheless, it can be prevented from freezing by a pressure of 138 tons to the square inch at 1.11° C. Any further lowering of temperature requires a proportional increase of pressure. In passing from the liquid to the solid state there is an increase in volume equivalent to one eleventh that of the liquid.

The boiling point is affected to a much greater extent. Under a normal pressure of 760 mm., water boils at 100° C., or rather, this value is arbitrarily assigned to it under these conditions, and all other values of temperature are referred to this and to the freezing point, 0° C., as standards. If the pressure is changed, the raising or lowering of the boiling point is directly in proportion.

Egg albumen coagulates only very slowly at temperatures below 100° C., and since the atmospheric pressure on the top of high mountains is quite a bit lower than at their foot, we see from the above why an egg takes so very much longer to cook at such elevations, if it cooks at all.

Water is a powerful refractor of light. This can be best shown by holding a stick in it in a slanting position, so that part of it protrudes above the surface. The stick appears to be bent. An interesting curiosity which makes use of this principle is the fish-eye camera, which makes things in front of it appear just as they would to a fish under water, that is, instead of a limited view of the scenery, or whatever it may be, everything within a radius of 180° is shown in the picture. The camera is a box filled with water; in the back is placed the plate, and the light enters through a small hole in the front.

Most substances, when dissolved in water, lower its freezing point. That is one reason why salt is used in the freezing mixture when making ice cream, the temperature of the ice salt mixture surrounding the can in a "freezer" often reaching a temperature of —21° C. In this connection it may be said that the stirring which is carried on serves two purposes; it brings the entire contents of the can into contact with the cold walls of it, which radiate the heat very rapidly to the outside; it likewise causes a more rapid crystallization of the contents, and in consequence makes the crystals much smaller.

Mention should also be made here of the undercooling which takes place when a solution is cooled. Instead of ice forming at the freezing temperature of the solution, by keeping it quiet and out of contact with the air, the solution will remain in the liquid state several degrees below that point. A small crystal of the solvent, or a sharp-edged body, or even a jar, will cause it to freeze suddenly.

Similar to this is a supersaturated solution, or one in which more of the substance is dissolved than it can ordinarily hold, a crystal of the dissolved substance, or the other treatments spoken of, causing crystallization.

Besides lowering the freezing point, dissolving a substance in a liquid also raises the boiling point. Much could be written concerning both phenomena but space does not permit. It is enough to say that the relationships established by a study of them are some of the most important of all science. Of course every substance has its own effect and the amount of each dissolved has to be taken into account as well.

When an acid, base or salt is dissolved in water, it is dissociated, that is, the molecules of the substance are split up into two parts, each part being charged with equivalent quantities of opposite kinds of electricity. These charged particles are called ions, and a compound which yields ions is called an electrolyte; all others, such as sugar, for instance, are called non-electrolytes. Solutions of the former will easily conduct an electric current, while solutions of the latter will do so no more than the pure water itself. Of all common liquids which dissociate substances, water has the highest power. It is dissociated itself only to the very slightest extent.

A fact which can be explained only by the theory of electrolytic dissociation is, that whenever an acid in solution is acted upon by an equivalent quantity of a base in solution, both solutions being dilute, and no matter what the acid or base, the same amount of heat is liberated in the reaction. The only thing here which can and does take place is for the hydrogen ion, which is the essential part of the acid, to combine with the so-called hydroxyl ion, the essential part of the base, to form a definite quantity of water, the same in every case, and hence giving off the same quantity of heat. The other parts of the acid and base remain unchanged, as ions, in the solution. In concentrated solutions, other factors come into play which necessarily cause the amount of heat to be variable.

We see from the above that water instead of being a side issue in chemical reactions, as we have been prone to place it, is really the most important and most fundamental thing in them. Moreover, it is made up of what constitutes both acid and base and yet has not the slightest trace of the properties of either. It is perfectly neutral.

When a soluble solid, no matter how great its specific gravity, is placed in the bottom of a vessel and is covered with water, it will in time diffuse through the entire liquid until the whole is perfectly homogeneous, even though the force of gravity is pulling continually against it, tending to keep it at the bottom. Diffusion is said to be due to osmotic pressure, but as this has never been explained satisfactorily, we are about as far from answering the question as to its cause as if we had left it alone. All we know of osmotic pressure is, that if we separate two solutions of different concentrations by a membrane, water will pass through the membrane from the more dilute to the more concentrated solution, which, if the latter side is enclosed, will set up a pressure on that side. This is called osmotic pressure, and there are certain laws governing it. These have been thoroughly studied and have been shown to correspond exactly to the laws of gases, but the cause for the pressure is as yet unknown. Diffusion is not a property of water only, but of all liquids. However, it has been studied in the case of water more thoroughly than in any other.

Another property of all liquids which has a special interest where water is concerned is surface tension. It is this property which causes a liquid to rise in a capillary tube and also aids in the formation of drops (pressure of the atmosphere likewise tending to reduce the liquid to the smallest, most stable geometric shape possible). It is due to capillarity that the minute blood vessels of living animals are supplied with blood, that a blotter sucks up ink, that moisture tends to come to the surface of the earth and that a good many other essential things of a similar nature take place. In fact we could not do without this important force.

*Solid Water.*—Here we have snow, hail, frost and ordinary ice.

Snowflakes are assemblages of minute crystals of ice formed from the aqueous vapor in the atmosphere. They vary in size from one fourteenth of an inch to one inch in diameter. The smaller ones are formed when the temperature is very low, but the larger ones not until it is near 0° C. They always assume a hexagonal shape and from each corner of the hexagon protrudes a ray at an angle of 60° to the ray on either side of it. This fundamental form is the same, no matter how much the crystals otherwise vary in shape.

Snow is only white to the eye because of the great refractive power of the crystals, which, when examined under the microscope, are seen to be transparent. It forms whenever a cold enough wave passes over a moist atmosphere, the water condensing out as crystals. Hail, on the other hand, is formed when the rain passes through a region of the atmosphere sufficiently cold to freeze it.

Just as the dew condenses out of the atmosphere on a summer night, on a winter night, when the temperature is below 0° C. frost forms. The action of frost as a geological agent need hardly be mentioned, it is so well known. Suffice it to say that it has played and continues to play a very important rôle in the changing of the earth's topography.

Water, when it cools, contracts until it reaches a temperature of 4° C., and then it begins to expand, slowly at first, until it very nearly reaches 0° C. and is about to freeze, then it increases very markedly and suddenly in volume. The specific gravity of ice is only 0.920, whereas at 4° C., pure water has a specific gravity of 1.000, that is, at 4° C., one cubic centimeter of pure water, in a vacuum, weighs one gram. Water is therefore used as a unit for specific gravity measurements. If water contracted all the way down to its freezing point, as most liquids do, in one cold winter every river, lake, etc., would be frozen up and would stay so, because of the ice being so much heavier than water and sinking to the bottom.

In freezing, water gives off a very large amount of heat, 79.06 calories for every gram of ice formed. The amount of heat liberated in freezing a gram of water, stating it in other words, is sufficient to raise the temperature of 79.06 times its weight of water from 0° C., to

1° C. Now we see why there is always a "warming up" just before a snowstorm.

When gases are allowed to expand suddenly, they cool themselves, taking heat from all surrounding objects. Also if a substance, like ammonia, which at ordinary temperatures is a gas, can be condensed by cooling and pressure to a liquid, and the pressure is removed, it will immediately begin to evaporate rapidly, and in so doing absorb a large amount of heat from everything around. Such a principle is used in the preparation of artificial ice.

Ice is often seen to have much dirt in it. If the water were stirred while freezing so that the crystals which separate are small, they would also be very nearly pure.

So much for solid, liquid and gaseous water. There are still one or two interesting things in connection with water, however, which do not bear directly on any one of these three heads.

Certain compounds have the power to crystallize with a greater or less amount of water—"water of crystallization," as it is called. Most of them can lose this water (or part of it) by heating them, and without detriment to the substances themselves. Examples of such are copper sulphate, sodium sulphate, alum, calcium chloride, etc. Some of these, like calcium chloride, if allowed to stand in the air, will attract moisture and become wet. They are said to be deliquescent. Others like sodium sulphate tend to lose their water of crystallization on standing open to the air. They are called efflorescent. There are still other compounds, called anhydrides, which take up water readily from the atmosphere, not as water of crystallization, but by so doing form a different compound, an acid. Phosphoric anhydride (phosphorus pentoxide) is an example of this kind, and it is the finest substance known for desiccating purposes. Dehydrated copper sulphate and calcium chloride likewise are extensively used.

Sugar, oxalic acid and a number of other substances lose water when being heated, but here the loss is quite a different one from that above. The compounds themselves are completely changed, showing that the water was in direct combination with them and that it was the fundamental part of them.

Many people know that water forms a large part of the human body and of the nourishment of the same, but few know what an enormous percentage of the whole this is. A human body weighing 150 pounds contains about 113 pounds of water (75 per cent., as was stated above), and requires daily for its sustenance, either as a liquid or combined with food, about 5.5 pounds of water. This equals more than half a gallon.

One can see from the following table from what source a large part of this water is derived:

| | Per Cent. |
|---|---|
| Bacon | 22 |
| Eggs | 65 |
| Butter | 11 to 16 |
| Richest Milk | 87 |
| Cucumbers | 97 |
| Salmon | 75 |
| Beef | 73 |
| Cabbage | 89 |
| Potatoes | 75 |
| Cheese | 25 to 50 |
| Strawberries | 90 |
| Apples and Grapes | 80 |

It would take volumes to tell of all the effects of water as a dynamic agent in geology—of the action of frost, of percolating waters, of rain, of waves, of rivers, glaciers, lakes, oceans, subterranean waters, etc., of all these and more on the exterior and interior of the earth. As justice can not be done to any one of these topics in a few words, they can only be mentioned here.

The prime importance of water to chemical reactions has already been spoken of above, but in conclusion, one or two examples will help to further show how really essential it is.

Concentrated sulphuric acid and metallic sodium will react with the most explosive violence if brought together in the presence of only a trace of water, but if proper precautions are taken to exclude every particle of moisture, drying them first and then bringing them together as quickly as possible, there will be no reaction whatever. The fuming of hydrochloric acid and ammonia in the presence of each other is proverbial in the chemical laboratory. They combine to form ammonium chloride, which appears in the form of a white cloud. Here again there is no combination, if the two are perfectly dry. Soda and tartaric acid (both solids) can be intimately mixed together, in solid form, without undergoing any reaction. But as soon as water is added, a tremendous effervescence takes place.

Many other cases might be cited, but these, as well as what has gone before, will, I hope, give some idea, at least, of the all importance of this wonderful yet common substance.

# PSYCHOTHERAPY IN FOLK-MEDICINE

By Dr. ABRAM LIPSKY

NEW YORK CITY

PSYCHOTHERAPY may look like a discovery of the twentieth century, but the truly remarkable thing about it is the extent to which it has been practised without being scientifically understood. It has been in the world since the remotest antiquity, nor has it ever left the precincts of civilization. A scholar spelling out an Assyrian inscription discovers a cure for rheumatism as follows: "Surround the patient with a circle of leavened meal, place his foot upon a reed-bearing dough, then put away the refuse-food. Take him seven time across the surrounding circle, saying 'Ea hath loosed, free the evil, Ea hath created, still the wrath, undo the knots of evil, for Ea is with thee! O Physician of the World! O Ninnissin! Thou art the gracious mother of the world, the leader of the underworld, the mistress of E-dubbo,'" etc. What is this but psychotherapy? A New England cure for rheumatism is to take a cat along to bed. That too is psychotherapy and rests on essentially the same principle.

The scientific person will say that these are interesting examples of heathen superstition, but that no one was ever cured by such means. That is just the question. In the light of our present knowledge, the probability is that both the Assyrian and the New England methods have worked—at least sometimes. Both are illustrations of the influence of thought upon the body. In the one case, faith of a religious nature dispels the physical symptoms; in the other, fear of the cat is probably the therapeutic distraction—or, as the psychologists call it, the "dissociation."

Popular psychotherapy has long known what science is only now finding out. The best known example of mind-cure is probably that of the toothache that ceases when the dental office is approached. If a man may cure his toothache by walking in the direction of a dentist's office, why may he not cure it by spitting into a frog's mouth, or scratching his gum with a nail and driving the nail into an oak tree, or pulling out with his own teeth the teeth of a dead man's skull, or solemnly repeating the lines:

> Christ passed by his brother's door,
> Saw his brother lying upon the floor,
> What aileth thee, brother?
> Pain in the teeth?

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Thy teeth shall pain thee no more.
In the name of the Father, Son and the
Holy Ghost!

Why should it be more difficult to believe that toothaches have been cured by each and every one of these methods as promptly as by the sight of a dentist's forceps? The therapeutic agent in each case is the same. It is psychical, and we call it "suggestion."

But if a toothache can be cured by psychotherapy, why not the ague? That too has often been done. Can modern psychotherapy produce a prettier illustration of the method of auto-suggestion than this—described in an old Saxon medical book? We are told that the sick man wrote the words "Febra Fuge" (fly away, fever) on a piece of paper and, beginning with the last letter, cut off a letter each day. The fever abated day by day and when the letter "F" finally fell, the ague disappeared. Fifty others, besides the narrator, were cured the same year by this method!

As the virtue of a dose of medicine does not depend upon the kind of spoon in which it is conveyed to the patient's lips so, a different way of administering suggestion for the ague proves in New England to-day of equal potency with that described by the early English writer. The patient goes out with a friend and looks on while the friend cuts down willow rods corresponding in number to the hour of the day. Each rod must then be burnt singly and as the last one turns to ashes the distressing symptoms disappear.

Among the country people of modern England a variety of devices for circumventing the ague are known. If you peg a lock of your hair into an oak and give a sudden jerk with your head, your ague will be transferred to the oak. Or, to mention only one other, you may take nine or eleven snails, string them on a thread, saying with each slimy bead, "Here I leave my ague." Frizzle them over a fire and as the snails disappear, so will your ague.

Observe how the last method accords with modern scientific psychotherapy. The practitioners of the Emmanuel movement tell us, in "Religion and Medicine," that when giving one's self a verbal auto-suggestion, it is well to accompany the words with some action, however trifling and absurd—the absurdity of the action, in fact, being rather something in its favor. For example, when you say to yourself: "I put away all worry," you might put an old shoe out of sight and think of your worry as staying with the shoe. The snail cure for ague obviously anticipates these directions. It takes advantage, moreover, in a very cunning way of another psychological discovery—the hypnotic influence of bright light when stared at fixedly. Most people now-a-days are familiar with this phenomenon from their experience in staring at strongly illuminated stereopticon screens. They know how difficult it is to keep awake—unless the lecture is unusually exciting. Now, suggestion is most effective on persons who are in a somnolent or hypnotic condition, and your credulous rustic, staring into the fire as the snails sizzle and repeating to himself, "Here I leave my ague," is performing a very pretty psychological experiment on strictly scientific lines.

Scientific psychotherapy has undoubtedly taken this hint of reinforcing verbal suggestion with a trivial action from popular practise. The device is perhaps best known in popular medicine as applied to the cure of warts. You strike the wart downwards three times with the knot of a reed as you make your auto-suggestion, or, you rub it seven times with the third finger of the left hand in the direction in which the sun moves; or, you wet your forefinger with saliva and stroke the wart in the direction of a passing funeral; or, you touch each wart with a pebble, place the pebbles in a bag and lose them—the finder getting the warts; or, you tie as many knots in a hair as you have warts and throw the hair away; or, you steal a piece of bacon, rub the wart and slip the bacon under the bark of an ash tree, thus causing the warts to disappear from your hand and appear on the bark; or, you get another, by hook or by crook, to count your warts, when they will pass over to him.

Let it not be supposed that the foregoing remedies are merely prescriptions, but not cures. Innumerable experiments have been made with them by persons who sincerely believed in their efficacy, and the evidence of their success is as abundant as that of the success of more academic methods. The great variety of methods—and those enumerated do not begin to exhaust the list—shows that the particular differences between them are of no consequence, but that any device based upon the faith of the patient may be employed to utilize the control which the mind, under certain circumstances, may exercise over the so-called vegetative processes of the human system. That the most powerful suggestion may fail of its object is, of course, perfectly well-known. A case is reported of a German peasant, unpleasantly endowed with too many warts, who stood on his head in a newly made grave. To a superstitious yokel this was an extremely powerful suggestion, but the warts remained.

Any one who is of the opinion that these remedies for warts can not be effective because they are so little countenanced by scientific medical authority, will see the matter in a new light if he will take the trouble to look up the remedies that are recommended by the medical authorities themselves. A standard medical work (Foster's "Reference Handbook of the Medical Sciences") names a few of them and dismisses the rest with the remark that they are too numerous to mention, as every physician has his favorite remedy. The diversity among these remedies being as great as among the popular cures, the inference seems justified that there is nothing inherently curative in the one class any more than in the other, but that they all depend upon that principle which is common to them all—the principle of suggestion.

The strange, the mysterious and the weird have great suggestive potency, and hence drugs culled at unearthly hours, during unusual conjunctions of the moon and planets, on St. John's or St. Agnes' Eve, have unusual curative properties. The rare stone bezoar, or bezar—a concretion found in the intestines of certain animals like goats—was believed in colonial New England to have magical powers. Any mysterious rite may be efficacious if linked with a vague but strong superstitious belief. In 1884, two children in Suffolk, England, between Needham and Barking, were reported cured of infantile hernia by means of the cleft-ash rite. The procedure was as follows: A sapling was split upward, beginning a few feet from the ground and tied at the top to prevent the cleft from extending all the way up. The cleft was held open and the child passed through three times, head downward, each time by a different person. The sapling was then bound up securely at short intervals. It grew together again—which was supposed to be the reason why the children recovered.

Miracles are sometimes due to the reinforcement of suggestion by the fascinatingly horrible, and hence the curative property of things associated with corpses, skulls, gallows, graveyards and so on. One of the many remedies for ague in England is to wear chips from a gallows around one's neck; for a wen one should go alone at night to the spot where a fresh corpse lies—preferably that of an executed criminal—and pass its hand over the wen. A poor woman living in the neighborhool of Hartlepool, England, some years ago was induced by a "wise woman" to go alone at night to an outhouse where a suicide lay awaiting the coroner's inquest and to hold the hand of the corpse on her wen all night. She died shortly after from mental shock. Another woman at Cuddesden, Oxfordshire, asked for the hand of a corpse in order to cure a goiter. Her father, she said, had been cured by the same means, the swelling having diminished as the hand mouldered away. In 1850, it was common for numbers of invalids in certain parts of England to congregate round the gallows in order to receive the "death stroke"—the touch of an executed criminal's hand. The practise declined because of the high fees the hangmen came to charge for applying the remedy.

There was a time when powdered mummy was a highly valued medicine throughout Europe. Carbonized and powdered animals are still used in China and Japan, as crushed bones once were in England. The celebrated chemist, Robert Boyle, relates, in his essay on "The Porousness of Animal Bodies," how, "having been one summer frequently subject to bleed at the nose and reduced to employ several remedies to check the distemper, that which I found the most effectual to staunch the blood was some moss off a dead man's skull (sent for a present from Ireland where it is far less rare than in most other countries) though it did but touch my skin till the herb was a little warmed." Mere contact with the gruesome object was sufficient.

Will it be objected that Boyle was deceived and that his nose-bleed could not have been stopped as he says it was? Let it be remembered that the possibility of controlling hemorrhages by suggestion has been demonstrated repeatedly by experiment on subjects under hypnotism. The Emmanuel practitioners have done it by their methods. The Bible reports a case, and the popular devices for stopping nose-bleed are about as numerous as for curing warts—one of the most favorite being to slip a cold key between the skin and the clothes. Boyle tells of another case, that of a young man, whose nose-bleed was stopped by the external application of an agate, and in his collection of household remedies he mentions, among other instances of suggestive therapeutics, the holding of a certain herb in the hand as another excellent measure against nose-bleed.

The horrible was relied upon by the Romans to give them the requisite psychic shock. They drank the blood of gladiators for epilepsy, and to-day in Denmark, China and Switzerland, curative suggestion for epilepsy, hydrophobia and consumption is obtained from the blood of decapitated criminals. The Egyptian kings took baths of blood to cure elephantiasis, and the Vikings drank from the skulls of their conquered foemen at solemn festivals. Next to the horrible, the loathsome and nauseating have been utilized. The bitter medicines that used to be prescribed by the old-fashioned doctors, and the vile compounds made from the excreta of goats, cats, dogs, mice and other animals owed their curative properties to the same principles. Nor have the worst of these medicines passed away from civilized lands, as a little inquiry among some of the latest arrivals from rural Europe has demonstrated.

Belief in the curative power of the means employed is the most important element in its success. We know now that it does not so much matter upon what the belief is based so long as the belief is strongly present. Faith, in former ages, was almost entirely at the command of religious ideas. To-day, faith in scientific conceptions and scientific authority has largely taken the place of religious faith. Let a man feel that a certain mode of procedure rests upon scientific principles, and the method, whether right or wrong, will have therapeutic value. Cures recommended by popular tradition are contemptuously dismissed as mere relics of ancient superstition, but any remedy administered with a show of scientific reasoning and authority is sure to produce results. A slight examination of the scientific remedies for whooping-cough will show how true are these observations.

The number of approved remedies for whooping-cough is about as large as for warts. Only a few will be mentioned here. Schlief used a bath of compressed air and reported eighty-five per cent. cured in fifteen seances. Gay, supposing that "the sublingual ulcer was the initial specific of whooping-cough, cauterized it with nitrate of silver and reports several cases cured in a short time!" Mohn has reported cases of whooping-cough "cured as if by enchantment" by the use of sulphur fumigators. The child is dressed in clean clothes and sent from the room, which is closed and fumigated with burning sulphur for five hours in the morning. After the room is aired the child sleeps there at night. One trial is generally sufficient for a cure! These observations have been enthusiastically confirmed by Manly.[1] Another physician cured 101 cases out of 169 by letting them inhale illuminating gas. Still another cured 219 out of 341 by the same method. Powdered benzoin cured 75 per cent. of one physician's cases. Seventeen patients were cured by another with boric acid and roasted coffee, and so on *ad infinitum.*[2]

There is, of course, no intention here of disputing the correctness of these statistics. They have been quoted only to show the similarity between the curative principle underlying them and that relied upon by a woman, probably of German descent, who was seen on the bank of the Schuylkill River, holding a live fish head foremost in the mouth of her child in order to relieve the child of the whooping-cough. The principle is plainly brought out again in the injunction to one seeking a remedy for his disease "to follow the directions given by a man riding on a piebald horse."

Religious emotion has undoubtedly been the most powerful agency known for energizing curative suggestion. We usually call it impotent superstition when it appears among lowly or primitive peoples. The Malay is patently and grossly superstitious when he recites: "Not mine are the materials, they are the materials of Kemah-ul-hakim. Not to me belongs this neutralizing charm. It is not I who apply it. It is Malim Karinim who applies it." But if he believes in Kemah-ul-hakim and Malim Karinim and is tremendously impressed by the formula he recites, we need not hesitate to believe that—sometimes—he is cured thereby.

The Englishman of Elizabeth's day was no doubt immensely superior in mental power to the poor Malay who has just been quoted. His religion was more logical and more efficacious than that of the Malay and perhaps his charms worked oftener. To the cold and unfeeling eye of science, however, the therapeutic principle in the charm, spoken by the Malay and that spoken by the Englishman is the same. This was the Elizabethan Englishman's charm for ague:

[1] Mohn in the *Revue Internationale des Science Med.*, November, 1886, and *The Practitioner*, August, 1888.

[2] Quoted in Foster's "Handbook."

When Christ saw the cross, He trembled and shaked and they said to Him, Hast thou the ague? And He said unto them, I have neither ague nor fever; and whosoever bears these words, either in writing or in mind, shall never be troubled with ague or fever. So help thy servants, O Lord, who put their trust in thee.

The same Englishman recited, in order to stop a hemorrhage:

So may it please the Son of God. So His mother Mary. In the name of the Father, stop, O blood! In the name of the Holy Ghost, stop, O blood! In the name of the Holy Trinity.

It is no longer possible, as was only recently the tendency, to deny all the miraculous cures ascribed to sarcred relics and to the touch of saintly persons. Science formerly had no explanation to offer and dismissed all such claims with contempt. They must now be admitted to be at least of possible occurrence. Authentic cures by healers not of the most exalted character have taken place in our own day almost before our very eyes. Faith in the power of a supposedly sacred personality has made them possible. In the hey-dey of royalty the divinity that was believed to hedge a king produced the undisputed cure of many a wretched invalid. Between three and four hundrd persons were said to have been cured by Queen Elizabeth annually of scrofula or the King's Evil. James the Second is reported to have cured three hundred and fifty at one time amid great pomp and ceremony—a circumstance that doubtless contributed materially to the success of the operation.

Religion after having been expelled by science from the field of therapeutics is now being invited back again. Science is obliged to admit that it was mistaken in its wholesale condemnation of appealing to religion in illness. And this change of attitude on the part of science has been brought about by the rise of two or three new concepts—suggestion, subconsciousness, multiple personality. That which formerly seemed absurd, now seems perfectly reasonable. It seems as reasonable that healers of the sick should make use of the immense suggestive reinforcement of religion as of the aid lent by the newer authority of science.

Unenlightened members of the medical profession in their desire to discount the achievements of psychotherapy declare that all that is of value in the new methods has long been known and used by regular practitioners. A large part of this claim is perfectly true. We all know that the success of many a prosperous physician is not due to his superior scientific equipment—in which he often is notoriously lacking—but to the faith inspired by his "personality." In some instances, gentle, soothing tones, in others, brusqueness and peremptoriness of manner, convey the very useful suggestion of great ability justified in its assumption of authority. The particular remedy prescribed after that is of no consequence.

But we must go a step farther. We must admit not only that regular medical practitioners have been making use of the principles of suggestion, but that the people at large, the common people, the ignorant and the superstitious, have had an intuition into their nature and have been practising psychotherapeutics, with more or less of success, from the dawn of history down to our own day. The practise of medicine is, even to-day, an art largely based upon empirical rules learned from the experience of the common people. Scientific medicine has in the past adopted into its pharmacopœia a great many of the "simples" cherished by the people, but has discarded their innumerable hints as to the value of psychotherapy. It is now beginning to turn to this neglected wisdom, to make use of the spiritual "simples," to learn what curative powers reside in the soul.

# THE STRUGGLE FOR EQUALITY IN THE UNITED STATES.

## IV

By Professor CHARLES F. EMERICK

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## The Courts and Public Opinion

### I

MANY are disposed to take exception to popular criticism of the courts. This point of view merits consideration because it is entertained by some who are genuinely progressive in spirit as well as by reactionaries. It is the position of those who think the tyranny of the majority is our greatest menace and who look upon the courts as the bulwark not only of property, but of personal liberty. It reflects the traditional respect in which the courts are held.

It is quite generally conceded that there are certain limitations to criticizing the courts which need not be observed in the discussion of other matters. During the trial of a case, remarks which obstruct the administration of justice are clearly out of order. Neither can the expression of views well be justified which counsel resistance to the decrees of the courts after they have once been rendered. So long as the decision of a court stands as the law of the land, it should be obeyed, unless an exception be made where matters of private conscience are involved. But this in no wise precludes bringing a similar case before the court with a view to having the point at issue reargued and the decision reversed, neither does it preclude popular discussion of the grounds upon which an objectionable decision rests. *Starte decisis* is a rule which admits of exceptions. The second legal-tender case is a conspicuous example. The view expressed by the Supreme Court in the Dartmouth College case has been "substantially modified, if not abrogated altogether."[1] Those who object to any and every criticism of court decisions forget that the law is not a hard and fast thing, but is all the time in the making, changing with the prevailing sense of right, and that discussion and criticism by the laity as well as by members of the bench and bar are helpful to this end. When there is great diversity of opinion among members of the bench upon a question, the general public can not well be denied taking part in the discussion, especially when some question of governmental policy is involved in regard to

[1] Christopher G. Tiedeman, "The Unwritten Constitution of the U. S.," p. 66.

which the public is confessedly the final arbiter. Moreover, since judicial interpretation frequently either enlarges or contracts the meaning of statutes and constitutions, the courts can hardly hope to escape without criticism. And where the courts occasionally declare legislative acts unconstitutional, as they do in the United States, popular criticism is almost inevitable. There is as little reason to expect the courts to escape unscathed by the sharp wing of criticism as to expect the soldier on the firing line in time of battle to escape the risks to which he is unavoidably exposed. It is useless to try to taboo the tendency of the popular mind to criticize the judiciary. The only recourse for either party to the controversy is to assume that the other is possessed of a rational nature and to try to contradict error with truth.

In the oft-quoted words of Ex-President Taft:

> The opportunity freely and publicly to criticize judicial action is of vastly more importance to the body politic than the immunity of courts and judges from unjust aspersions and attack. Nothing tends more to render judges careful in their decisions and anxiously solicitous to do exact justice than the consciousness that every act of theirs is to be submitted to the intelligent scrutiny and candid criticism of their fellow-men. In the case of judges having a life tenure, indeed, their very independence makes the right freely to comment on their decisions of greater importance, because it is the only practicable and available instrument in the hands of a free people to keep such judges alive to the reasonable demands of those they serve.

These observations are especially true in a country where the springs of authority are supposed to reside in and to issue from the people. In a country where the divine right of kings is in vogue, there is a certain consistency in placing popular criticism of the courts under the ban, but such action is incongruous in a country committed to the idea of popular rule. The courts are ordained and established by man to promote the ends of justice, and since the creature can not be greater than its creator it is within the realm of the possible for the people to abridge the power of the courts and to reconstitute them on a different basis. The constitution leaves the establishment of courts inferior to the Supreme Court to the discretion of Congress. The original jurisdiction of the Supreme Court is specifically limited to cases affecting ambassadors, other public ministers and consuls, and cases in which a state is a party, and its appellate jurisdiction is subject to such exceptions and such regulations as Congress shall make. In providing for its own amendment, moreover, the constitution makes no exception of the judicial system for which it provided, but frankly admits that in this as well as in other respects it may become outgrown and require modification. Certain current writers appear to think that the framers of the constitution uttered the last word of wisdom upon the judiciary. The framers themselves did not entertain this delusion. The last Republican platform recognizes that all is not well with the courts, and accordingly favors legislation to the end of preventing "long delays and the tedious and costly appeals which have so often amounted to a denial of justice in civil cases and to a failure to protect the public at large in criminal cases." Still more significant is the approval of "such action as may be necessary to simplify the process by which any judge who may be found to be derelict in his duty may be removed from office."

## II

The current tendency to criticize the courts is nothing new. It has existed ever since the foundation of the government. Jefferson denounced the decision of the Supreme Court in Marbury *v.* Madison. Jackson vetoed a bill renewing the charter of the United States Bank on the ground that it was unconstitutional, although the Supreme Court had pronounced a similar bill constitutional, and Lincoln strongly dissented from the Dred Scott decision. Moreover, in at least three instances the President has gone so far as openly to disregard an order or a decision of the Supreme Court. Jefferson refused to answer to a subpœna issued by Marshall for his appearance as a witness at the trial of Burr. Jackson's celebrated remark, "John Marshall has rendered his decision, now let him enforce it," will probably never be forgotten. Lincoln ignored the opinion of Chief-Justice Taney that the suspension of the writ of habeas corpus by presidential proclamation was unconstitutional. States have also refused to obey the decisions of the court.

Criticism of the courts is especially rife at present and promises to become still more common. First, the readiness with which injunctions are issued at the behests of employers in controversies between capital and labor irritates the working classes. Blanket restraining orders issued now and then without the parties enjoined having a chance to be heard in court and occasional instances in which peaceful persuasion is placed under the ban stir up bad blood and create the impression that the courts are the tools of the employing class. Amendment number twenty-two submitted to the voters of Ohio in 1912 contained the following:

> No order of injunction shall issue in any controversy involving the employment of labor, except to preserve physical property from injury or destruction; and all persons charged in contempt proceedings with the violation of an injunction issued in such controversies shall, upon demand, be granted a trial by jury as in criminal cases.

This amendment failed to carry. Nevertheless, the large vote which it received indicates much dissatisfaction with the manner in which the courts at present issue injunctions and punish for contempt in labor cases. This amendment received 240,896 votes as compared with 257,302 cast against it, though in limiting the injunction to the preservation of physical property it forbade its use to protect the good-will of a business or the lives of the community from intimidation and acts of violence.

In the second place, the courts have become the targets of adverse criticism by declaring social legislation unconstitutional. One has but to recall the popular disapproval aroused in recent years by the decisions of the New York Court of Appeals. Laws that prevented the manufacture of tobacco in tenement-houses, safeguarded life against dangerous machinery, limited the hours of labor of women in factories to ten hours a day for six days in the week, and the Workingmen's Compensation Act have been held unconstitutional. These decisions have done much to provoke the belief that the courts are unsympathetic with humanitarian measures and that they unwarrantedly interfere with legislative discretion.

> The people believe in their courts, they admire and love many of their judges, yet they feel, vaguely, perhaps, but persistently, that something is wrong about a judicial system under which a few men obstruct the will and the needs of the many on matters which seem to involve no question of substantial right at all, so far as individuals are concerned, but only divergences of view as to what is expedient and proper so far as society, as a whole, is concerned.[2]

A third fact, and one often emphasized by Ex-President Taft, concerns the almost interminable delay incidental to judicial procedure in many parts of the United States, the practically endless opportunity for appeal, the frequency with which the outcome of litigation turns upon some technicality of the law and not upon justice, and the fact that the winner in a lawsuit is often the man with the longest purse and not the man with a just cause. The legal profession is prone to procrastinate. Compliance with the forms of law instils the habit of delay. To postpone action until an important witness for the opposing side moves away or dies, or until some other desired event happens, is a favorite device. A banker of long experience tells me that the average business man takes considerably less time to settle an estate than the average lawyer. In the state of New York since 1848, three out of every five cases have been decided upon some point in procedure in place of being decided upon their merits. In other words, the doing of justice has been subordinated to the enforcement of technical rules. The plaintiff in a divorce case failed to secure a decree because the words, "Action for divorce," were written on the back in place of on the face of the summons to her husband, as required by the statutory code. If the action had been to recover a penalty, the "general reference to the statute" should have been placed upon the back of the summons.[3] Failure to do justice, consequently, is sometimes due to the fact that the statutory codes governing procedure leave the courts no discretion. When one considers how much the usefulness of the Interstate Commerce Commission was for years impaired by judicial obstruction, it is

[2] William L. Ransom, "Majority Rule and the Judiciary," p. 36.

[3] George W. Alger, "Swift and Cheap Justice," *The World's Work*, Vol. 27, 1913, pp. 56–57.

apparent how frequently the law's delay in the case of the ordinary man must defeat the ends of justice. So uncertain and expensive is justice secured at the hands of lawyers and courts that many men of affairs settle their controversies by arbitration. The ordinary man, unless of a contentious nature, often finds the cost of justice prohibitory. One result is to encourage aggression by wrongdoers. In trials before Justices of the Peace, the defendant frequently permits judgment to be rendered by default, and a year or two may elapse before the case is tried in a higher court. Needless appeals and retrials may result in the lapse of a much longer time before the case is finally decided. "Litigation for the sake of litigation ought to be discouraged. But this is the only form of petty litigation which survives the discouragements involved in American judicial organization and procedure."[4] Moreover, many members of the legal profession to their discredit are averse to changing a system which inures to their personal advantage. It is little wonder, consequently, that among the well-established planks in the platforms of the Socialist party is the demand for free justice. To the end of remedying the existing condition the people of Ohio, in 1912, provided for one trial and one review by amending the state constitution.

In the fourth place, the courts are not organized on a business basis. The records which disclose the comparative amounts of work done by the different members of the bench are usually sadly deficient. The Municipal Court of Chicago "is the only court, as yet, which is so organized as to be able to furnish adequate statistics of judicial administration."[5] There is too much piecemeal dealing with cases by judges whose jurisdictions overlap. As many as twenty-two different justices have heard different proceedings in a single cause.[6] There is a lack of supervising officers whose duty it should be to place the several members of the bench where they can do the most effective work. The judges in the circuit and superior courts of Chicago "draw lots to see who shall hear chancery cases. There is no possibility of specialization. They do their work in the criminal court for a year at a time in rotation." The Courts of Common Pleas in Philadelphia "are split up into five air-tight compartments, each an absolutely distinct court," with no possibility of transferring cases from one court to the other. In some courts the time of lawyers and litigants is needlessly wasted by calling cases from day to day that are too far down the list to stand any chance of trial.[7] Another mistake lies in depending upon incompetent tribunals to dispense justice in petty cases, such as those presided over by the ordinary Justice of the Peace. Individual judges of the same court

[4] Professor Roscoe Pound, "The Administration of Justice in the Modern City," *Harvard Law Review*, Vol. 26, 1913, p. 320.

[5] *Ibid.*, p. 315.

[6] *Ibid.*, p. 314.

[7] George W. Alger, *op. cit.*, Vol. 26, 1913, pp. 658, 662 and 663.

occasionally block each other. In the history of the Erie Railway, the interference of some of the Supreme Court judges of New York with each other assumed scandalous proportions. The contending parties instituted proceedings before competing judges friendly to their respective interests.[8] The popular impression that the courts are organized to give business to lawyers and to afford jobs to place-hunters rather than to promote the ends of justice is by no means groundless. The cost of our judicial system to litigants plus the excessive cost saddled upon the taxpayers will sooner or later attract the scrutiny of the public. Social legislation that calls for increased expenditures and upon which men have set their hearts will compel economy in our judicial expenditures.

Recent events, however, afford ground for hope. The efficient organization of the Chicago Municipal Court shows what can be done. Municipal Courts are gradually taking the place of those over which Justices of the Peace preside in other cities. The Police Magistrate's Court in New York City has been reorganized in two divisions each of which has a directing head. The dominant note of the reports and proceedings of The American Bar Association manifests less pride in the courts and is more given to criticizing the law and its administration. The courts are suffering the consequences of too much veneration. They need the stimulating effect of a more critical public opinion. "The law needs perennially an infusion of ideas from outside professional circles."[9]

In the fifth place, the seat of authority is gradually shifting toward the popular mind. This is a fact of fundamental importance and is one with which it is as useless to quarrel as with the tides. Socialism and trade-unionism are redistributing the center of authority. Our educational system, the railroad, the steamship, the telephone and telegraph, the postal system, the newspaper and cheap magazine, in short, all the facilities which quicken the popular intelligence, are opposed to making a fetish of the constitution and of the courts. Judicial infallibility as well as infallibility in the matter of religion is out of keeping with the spirit of the times. It is too late to return to the theory of dependence according to which

> the lot of the poor, in all things which affect them collectively, should be regulated *for* them, not *by* them. . . . The poor have come out of leading-strings, and can not any longer be governed or treated like children.[10]

Sixth, the demands made upon the courts are becoming more exacting. A keener conception of justice is spreading throughout society. Busi-

[8] Charles F. Adams, Jr., and Henry Adams, "Chapters of Erie and other Essays," pp. 1–99 passim. Pages 18–24 are especially illuminating.

[9] Professor Roscoe Pound, *op. cit.*, p. 319.

[10] John Stuart Mill, "Principles of Political Economy," edited by W. J. Ashley, pp. 753 and 757.

ness conduct once in perfectly good standing is being called in question. Are sweatshop conditions just and right? is a question asked on every hand. The American people are waking up to the fact that an abundance of free land rather than the excellence of their institutions has been the secret of much of the success which they have achieved, and that the disappearance of the former renders reliance upon a happy-go-lucky system of dispensing justice no longer prudent. Moreover, justice has ceased to dwell among the clouds and a larger measure of it is within the grasp of the ordinary man if he but asks for it. People are demanding justice here and now and can no longer be put off with promises of bliss in the hereafter.

Modern civilization is imposing heavier burdens upon the courts in still another way. The growing complexity of the environment has greatly increased the sum total of human relations and changed the character of many old ones. The relations between employer and employee when the two worked side by side bore little resemblance to what they are to-day in connection with a trunk-line railway or gigantic trust. The staple necessaries of life which every community once produced for itself are now supplied through the portals of the world market. Producer and consumer have ceased to be neighbors and the personal relations which once obtained between them have ceased to exist. The problem of regulating the relations which exist between the public on the one hand and the railways, trusts and labor organizations on the other baffles the keenest minds.

Again, we have become less exultant as a people, less confident of our future, less disposed to leave our destiny as a nation to drift without a guiding hand and purpose. There is a growing sense that a

> better future, just in so far as it is better, will have to be planned and constructed rather than fulfilled of its own momentum. . . . The way to realize a purpose is, not to leave it to chance, but to keep it loyally in mind, and adopt means proper to the importance and the difficulty of the task.[11]

The suspicion is growing that the self-interest of the individual is not at one with the public welfare. There is misgiving lest barriers arise to obstruct the process whereby men of ability, no matter how humbly born, have hitherto risen to positions of trust and leadership in the community. There is fear lest a system of caste get such a foothold that young men of promise will cease to aspire and rest content with the stations in life in which they happen to be born. There is a keener sense of social responsibility and less of a disposition to hold the individual responsible for human failure. Poverty is not regarded as a condition to which large numbers of men are hopelessly condemned. In short, an atmosphere of seriousness has swept over the nation and imposed more difficult tasks upon the courts.

[11] Herbert Croly, "The Promise of American Life," pp. 6 and 24.

A democratic ideal makes the social problem inevitable and its attempted solution indispensable.[12]

Seventhly, the popular suspicion that judicial decisions unduly favor the interests of corporate wealth is apparently increasing. The reasons are not far to seek. The road to a judgeship often lies through an attorneyship for some great corporation, and an unconscious if not a conscious bias is believed to follow a man when he ascends the bench. Association with the comfortable and well-to-do is thought to exert a similar influence. The indiscretion of certain prominent jurists in accepting Pullman and other railway passes, and in going on junkets as the guests of railway attorneys whose clients either have or some day may have cases in court naturally arouses suspicion. Active participation in politics by members of the bench, nepotism in the appointment of railway receivers and the distribution of other choice plums, the auctioning off of judicial nominations to the highest bidder, promotions to judgeships as a reward for services rendered political machines closely allied with corporate interests,—these and other infractions of the law of fair play have lessened the prestige of the courts. Fortunately, however, instances of corruption on the bench are still believed to be the exception and not the rule.

In the eighth place, the most common criticism of the courts does not concern their integrity, but "the comparative inflexibility of the judicial mind, a certain blindness to the changing social and economic order, an exaggerated veneration for ancient principles of law, established under conditions which no longer apply."[13] Tradition and precedent are all well enough as guides in a stationary environment, but they lose much of their utility amid shifting conditions. It is worthy of note that some of the courts are less frequently the target of adverse criticism than others, and the Supreme Court probably least of all. More or less florid rhetoric is occasionally employed in denouncing the decisions of that body, but I do not recall any decision within a lifetime against which the taint of dishonor has been brought by any one entitled to belief. Moreover, partly because long years of service on the bench make for a public rather than a private point of view, and partly because climatic, geographical and economic conditions in the United States are more diverse than in any one state, the decisions of the Supreme Court are relatively flexible.[14]

The legal precedents which have arisen amid rural conditions may prove a misfit in a large city. The reasons are apparent. The rural mind inclines to a minimum of public control. It is jealous of authority. It emphasizes the rights of the individual rather than the social interest. It explains the presence of Bills of Rights in the con-

[12] *Ibid.*, p. 25.

[13] Walter E. Weyl, *op. cit.*, p. 112.

[14] Frank J. Goodnow, "Social Reform and the Constitution," pp. 330–331.

stitutions of the several states. It also accounts for our system of checks and balances. A modern urban community, if left to itself, would hardly shackle its power to act by such devices. The Kentucky mountaineer who carries his individualism to the point of taking the law into his own hands in place of relying upon the regularly constituted authorities is the forerunner of the present rural point of view. Moreover, the farmer is less familiar with social and economic changes than people who live in cities. Agriculture is less subject to revolutionary changes in machine production than manufactures. Tradition is more potent in the country than in the city. The opportunity for keeping public opinion abreast of the times by publicity and discussion is better where population is dense than where it is sparse. The vote on the forty-two amendments to the constitution of Ohio submitted to the voters in 1912 illustrates the condition of the rural mind. Of the thirty-four amendments adopted, all, save woman suffrage, carried in the twelve leading urban counties of the state. Nineteen of these amendments would have been defeated without the vote of the urban counties. Seven amendments were defeatd "in spite of the favorable majorities cast by the cities."[14a] The urban counties contain less than half the population of the state. Nevertheless, "every amendment that passed received its heaviest majority in the cities."[14b]

The average farmer can have little conception of the problems which confront the modern city. Rural constituencies are proverbially conservative on questions outside of their experience. In a law-abiding country community, a suit for damages may prove an adequate remedy for occasional infractions of the law, but in an urban environment far more latitude should be given administrative officers, such as factory, tenement-house and meat inspectors, to prevent anti-social practices. The modern city is mainly a development of the last fifty years. It is not surprising, therefore, that the judicial mind steeped mainly in the old traditions of the law sometimes fails to do justice. The Court of Appeals in New York has usually been made up almost entirely of what are called "up-state" judges. The Supreme Court of Illinois consists of seven judges elected from as many districts. The seventh district includes the city of Chicago and comprises 46.4 per cent. of the population of the state. Courts constituted in this way may easily blunder in deciding cases that affect the metropolis.

Professor Roscoe Pound, of the Harvard Law School, says:

> Almost all of the backwardness of American courts with respect to social problems and social legislation has been backwardness with respect to social problems of our cities and social legislation for our cities. Is it not obvious what a difference it would have made if the every-day social relations of the judges of our highest courts had been in New York instead of Albany, Chicago

[14a] Robert E. Cushman, "Voting Organic Law," *Political Science Quarterly*, Vol. 28, 1913, p. 222.

[14b] *Ibid.*, p. 220.

instead of Springfield, St. Louis instead of Jefferson City, and so on? Is it likely that a court sitting in New York City would have gone wrong in construing tenement-house legislation? Questions may well seem abstract and academic in Albany or Springfield that are concrete and practical in New York or Chicago. Judges there may well fail to appreciate the practical aspects of legislation which a court sitting in the metropolis, whose judges met and talked with social workers in the ordinary intercourse of society, would perceive. Our rural capitals are not a little to be blamed if the course of justice in our highest court with respect to urban problems has been guided largely by judges who looked at them through rural spectacles.[15]

Finally, the difficulty of amending the constitution of certain states, and especially the federal constitution, is bringing the judiciary into disfavor. When the nation consisted of a homogeneous population confined to the Atlantic states, the amendment of the constitution offered no insuperable difficulty. The framers of the constitution could not have intended to provide the country with an inflexible instrument, for "they were trying to escape from the restraints of a still more rigid constitution."[16] None the less, with the growth of slavery, the admission of new states, the development of manufacturing, mining and commerce, and the consequent emergence of sectional differences, the difficulty of amendment has increased until vetoes interposed by the courts have become less and less suspensory and more and more absolute in character. Nearly eighteen years were required to restore to Congress the power to levy an income tax, though it was generally supposed that Congress possessed this power until the adverse decision of the Supreme Court in 1895. As a matter of fact, Congress imposed an income tax in 1861 and the Supreme Court held it constitutional.[17] For more than two generations there was an increasing demand for the election of United States senators by popular vote, but so difficult did formally amending the constitution prove in this case that years before it was accomplished election by the legislature became a mere form and was superseded by direct primaries in many states. No other important country is operating under such a rigid constitution. Amendment by interpretation is occasionally practised by the courts, but too infrequently to afford an adequate remedy. Besides, as with religious creeds, forced construction sometimes makes a laughing-stock both of the constitution and the courts. The result is that the American people are barred from passing measures which many other countries deem necessary to their well-being. Among such measures are "pensions or public insurance in case of old age, accident or sickness where the recipient of the pension or insurance is not actually a pauper and where the fund from which such pension or insurance is obtained is derived from taxation; the regulation of the hours of adult male labor in any but the

15 *Op. cit.*, pp. 325–326.

16 Professor Monroe Smith, *North American Review*, Vol. 194, 1911, p. 658.

17 Israel Ward Andrews, ''Manual of the Constitution,'' revised in 1892, p. 83.

evidently most dangerous trades; effective regulation of the use of urban land; and the use of the powers of taxation and eminent domain for the purpose of furthering schemes to provide aid for the needy classes."[18]

## III

Current discussion during the last presidential campaign centered a good deal about the recall of judges and "the recall of judicial decisions." Many high-minded and conscientious men strenuously object to both of these proposals. But whether they mark so radical a departure from the present order as to be wholly out of the question is more than doubtful. Every advance in popular government has excited the fears of many God-fearing men. The abolishment of the property and religious qualifications for the suffrage meant to many the speedy downfall of our institutions. An electoral college merely registering the will of the people seemed the height of folly to most of the fathers. But a short time ago, the limitation of the veto power of the lords in England seemed impracticable. These facts suggest that the recall of judges and "the recall of judicial decisions" are matters which a rational being may at least dispassionately consider.

The recall of judges by legislative address already exists in several of the states, but it is rarely exercised. Moreover, in the states where the judges are elected and are subject to reelection at the end of their term of office, one would expect to find numerous and glaring examples of the evils like those which the judicial recall is supposed to invite, and yet I am not aware of a popular movement in any one of these states which looks towards electing judges for life or substituting an appointive for an elective judiciary.[19] On the contrary, in some of these very states there is a formidable movement for the judicial recall. It is true that the public has now and then foolishly dispensed with the services of an eminent jurist for one that is grossly incompetent. The loss of Judge Cooley to the Supreme Court of Michigan is a conspicuous instance. But then again, Judge Gary who presided at the trial of the Chicago anarchists was repeatedly reelected. The disadvantages which attend an elective judiciary are apparently more than offset in the popular mind by the advantages. The actual working of the judicial recall would manifestly depend very largely upon the safeguards thrown around its operation. After all, the stronghold of the judiciary does not lie in its technical independence, but in the traditional respect in which it is held. So great is this respect that it is probable the recall would rarely be applied to judges save on the ground of malfeasance in office. Probably no state can boast of a more independent and upright judiciary than Massachusetts, where judges can be removed by the governor and

[18] Goodnow, *op. cit.*, p. 332.

[19] In 1905, judges were elected by popular vote in thirty-three states. See Goodnow, *op. cit.*, p. 340.

council without a hearing and without assigning the ground for removal upon the address of a bare majority of the legislature.[20]

The issue is not between those who want a judiciary that is subject to the passing whims of the hour and those who do not. Every right-minded man wants a fearless and upright judiciary, and the only question is how to secure one that is not at the same time the slave of precedent. Mr. Roosevelt's remedy for this state of mind is "the recall of judicial decisions," limited, however, to the recall of decisions rendered by state courts. This would require amending the constitutions of the several states so that a legislative act involving the exercise of the police power, if held unconstitutional by the supreme court of a state, could be submitted to the people and the decision of the court either upheld or reversed. Or the right of recall might be limited to instances where an act is held unconstitutional by a state court on the ground that it deprives one of life, liberty and property without due process of law in contravention of the state constitution. If the decision of the court were reversed, the legislative act would thereafter be excepted from the constitutional prohibition. "This," Judge Grosscup points out, "would be amendment and not construction, the exercise of legislative and not of judicial functions by the people."[21] Strictly speaking, therefore, the proposal is not a recall of judicial decisions at all, but a plan for amending the constitutions of the several states. In other words, a decision handed down in any particular case prior to the time "the recall" or amendment took effect would be *res adjudicata,* but in similar cases arising thereafter the state courts would be obliged to uphold the constitutionality of the statute. The state constitutions as amended in accordance with this plan would be subject to all of the guaranties of the federal constitution just as they are at present.

It is difficult to see why any one should be either wildly enthusiastic or vindictively opposed to such a plan. It involves no new principle. It assumes that the sovereign power rests in the people and that constitutions rightly emanate from and embody the deliberate will of the majority, assumptions that are fundamental to the American constitutional system. There is no more reason why it would result in hasty and ill-considered changes in the constitutions of the several states, or why it would enable a majority to ride rough-shod over the rights of a minority, than is possible under the method of amendment now in vogue. It preserves the tradition in accordance with which the courts declare legislative acts unconstitutional. It would permit the decision of a court to be reversed only in the sense that the eleventh and sixteenth amendments to the constitution reversed the decisions of the Supreme Court. A mode of amending the state constitutions that meets with the approval of a jurist of such well-known conservative tendencies as ex-

20 William L. Ransom, *op. cit.,* pp. 85–86.

21 Charles H. Hamill, "Constitutional Chaos," *The Forum,* July, 1912, p. 50.

Judge Grosscup can hardly be ultra-radical. As compared with the "constitutional initiative" which exists in California, where an amendment may be initiated by the people without prior formulation by the legislature, Mr. Roosevelt's proposal is conservatism itself.

Moreover, it is conservative in another respect. It is customary at present to abrogate completely the "due process" clause of a state constitution in such states as New York, so far as legislation to safeguard the lives, health or safety of employees is concerned, to enable the legislature to pass a workingmen's compensation law that will stand fire in the courts. That is, the state constitution is amended so as to give the legislature *carte blanche* in enacting such a law. Beyond doubt, a plan of amendment which enables a particular statute to be validated and leaves the "due process" clause of the state constitution stand against radically different legislation upon the same subject is the more cautious going. A discriminating advocate of the "recall of judicial decisions" aptly says:

> We do not wish to take down *all* constitutional restrictions on an entire class or category of legislation, good or bad, merely to take one sound, wise law out from under the ban. The people do not seek a safety-valve like the whistle on the Mississippi River steamboat described by Lincoln, which stopped the boat whenever the whistle was blown, nor do they want the safety valve of orderly progress in legislation "*tied down*" beyond the power of the people to utilize when needed. A method of dealing only with the specific statute when the need arises, rather than framing broad generalizations to take all similar statutes out of the prohibition pronounced by the court, has much to commend it to the conservative common-sense of our citizens. . . . Is it not better that the people should pass . . . upon the public necessity and social justice of a *particular law* which some court may reject, than that, in advance and for all time, broad and paralyzing terms of general exemption should be written into our historic guaranties? Why break out a window, instead of merely raising it, for ventilation? [22]

"The recall of judicial decisions" has been rejected by many on the ground that it is too radical. So far as I am aware, Colorado is the only state thus far to adopt it.[22a] In the long run, it may be rejected because it is not radical enough. Many have erroneously supposed that it contemplates submitting to popular vote the issues in a case that has already been tried in court, whereas it merely provides a method for determining the rules that shall govern the trial of similar cases in the future. If adopted, the courts could declare unconstitutional every material increase in a piece of social legislation and necessitate a referendum. In no event, could the people of a state do more than bring the interpretation of the "due process" clause of their fundamental law abreast of the views of the Supreme Court, and they could not do even this if the highest court of a state held a legislative act contrary to the

[22] William L. Ransom, *op. cit.*, pp. xv–xvi.

[22a] A. Lawrence Lowell, Public Opinion and Popular Government, Appendix B, p. 374.

same clause in the federal constitution. For the federal judiciary act makes no provision for the review by the Supreme Court of such an adverse decision, and it therefore stands as the supreme law of a state beyond the power of its people to recall. If the New York Court of Appeals, for example, held an act contrary to the "due process" clause of the state constitution, the people of the state could reverse the decision, but if the same court held the act contrary to the same clause in the federal constitution the decision could not be "recalled" by the people.[23]

The recall of judges and "the recall of judicial decisions" are not so absurd as to be impossible. Three states have already adopted the former, and the failure of public opinion thus far to take up with the latter may be due partly to the novelty of the proposition and the fact that it became the football of heated controversy during the last presidential campaign. The extraordinary power of the courts to declare legislative acts unconstitutional should not be forgotten. When so level-headed an organ as *The Survey* says that the decisions of the New York Court of Appeals overthrowing the workingmen's compensation and two other acts "should be held up to the reprobation and scorn which they deserve,"[24] surely it is time for every one to give heed. If members of the bar opposed to "the recall of decisions" are wise, they will not content themselves with resolutions of condemnation. They will propose other remedies that are more appropriate. They will try to lessen the abuses which attend the issue of injunctions, and to expedite the trial of cases. They will do everything possible to free the bench from corporate and other sinister influences and to elevate its character. They will use their influence to amend the Judiciary Act so that state laws held contrary to the constitution by the highest courts of the several states may be reviewed by the Supreme Court. They will strive to have the courts try as hard to find laws constitutional as they sometimes appear to try to hold them invalid. They will endeavor to make it more easy to amend the constitution and the constitutions of such states as Pennsylvania and Illinois. They will duly consider requiring more than a mere majority of a court to declare a law unconstitutional. If a legislative act should be presumed constitutional until the contrary is proved beyond a reasonable doubt, something approaching unanimity among the members of a court may well be required to declare it unconstitutional. It is noteworthy that the people of Ohio in amending their constitution in 1912 adopted a provision to this effect. Amendment number nineteen includes the following:

> No law shall be held unconstitutional and void by the supreme court without the concurrence of at least all but one of the judges, except in affirmance of a judgment of the court of appeals declaring a law unconstitutional and void.

[23] W. F. Dodd, *Political Science Quarterly*, Vol. 23, 1913, pp. 7–10.

[24] Vol. 27, 1912, p. 1895.

## IV

In interpreting the "specific clauses" of our organic law, the courts experience comparatively little difficulty, but in interpreting the "general clauses" there is a fair chance that they may go astray. The constitutional prohibition that no state shall grant letters of marque and reprisal, coin money, etc., is not easily misunderstood, but the words of the fourteenth amendment which prohibit the states from depriving any one of property without "due process of law" has a good deal of flexibility of meaning. In a general way, it means that no one shall be deprived of property without a hearing or without compensation unless "the general interests of the community" demand it. The interpretation of such a clause necessarily involves the exercise of legislative discretion.

> Under the constitutional system as developed in this country the political philosophy of the judges is a matter of vital importance. They are policy determining officers, because they have power to declare null and void "on principles of constitutional law which are scarcely more than general moral precepts," laws enacted by the legislative authority. It is this function of declaring laws unconstitutional, especially as violative of broad and undefinable guaranties that "no one shall be deprived of life, liberty or property without due process of law," which has made the courts in this country essentially law making bodies, determining in the end what legislative policies shall or shall not be adopted. . . . There are under this clause no fixed or definite standards for determining what laws are constitutional and what are unconstitutional. Judges are thus exercising political functions, without corresponding political responsibility; and inasmuch as such functions are being exercised in a manner opposed to public sentiment, popular criticism of the courts is a necessary consequence.[25]

What is necessary to the public health, safety and morals is a question which should be determined in the light of the particular facts and circumstances existing at a given time and place. These are matters which "the prevailing morality or the strong and preponderant opinion" of society should properly control.

> A tenement-house act might seem absurd in Arizona, a statute regulating the grazing of sheep might seem absurd in Greater New York. . . . A law regulating the hours of labor in canneries would have been laughed out of the legislature or the courts seventy years ago, for the housewife did her own canning in the wholesome conditions of her own kitchen; yet such a statute may be very necessary under the conditions now obtaining, for example, in the fruit-growing regions of central New York.[26]

A *laissez-faire* philosophy may have answered the needs of our grandparents, but it has little place amid the conditions of modern life. The political philosophy which holds that "that country is governed best which is governed least" may have been all well enough on the frontier, but it is out of date in an age of cities. When man's relations with his fellows were few and far between, comparatively few restraints upon the individual answered every purpose, but in the crowded center and in a time when the railway, the telephone and the telegraph have vastly

[25] W. F. Dodd, *op. cit.*, pp. 3–4 [26] William L. Ransom, *op. cit.*, p. 135.

multiplied social relations a new social creed is demanded. A social philosophy that originated in the age of homespun does not fit the needs of a factory age.

There is no reason why the legal precedents adapted to conserving the welfare of society amid the simple conditions of the past should determine what is permissible amid the complex conditions of to-day.

> We can not regulate modern gas and electrical corporations by decisions rendered in the days of the tallow dip; we can not adequately control four-track steam railroads merely by the law of the stage-coach and the public inn; we can not be content to have our labor legislation forever checked and thwarted by the decisions of a few men out of the many, and those few, not men of to-day, accountable in any way to their fellows, but dead men, who lived in the days when manufacture was carried on only in wholesome towns and villages, on a small scale and without modern ''division of labor''—in fact, when few persons even *cared* whether women worked long hours, or little children toiled in mines, or workers breathed deadly fumes as they worked. . . . Of course, if we try to find in 1770 precedents to sustain 1912 legislation as to ''sweat-shops'' or ''underground bakeries'' we shall not find any, for there were no ''sweat-shops'' or ''underground bakeries'' then, and no one would have cared or tried to pass laws about them then if there were.[27]

To require the courts to decide questions of legislative policy necessarily exposes them to attack, and few things would contribute more to maintain their hold on the good-will of the public than to relieve them from this responsibility. Either a more complete separation of legislative and judicial functions is necessary, or the courts should be kept better informed concerning the seasoned opinion of the community. The opponents of "the recall of judicial decisions" should consequently welcome any and every educational process that helps to keep the courts informed and thoroughly in sympathy with the progressive thought of the age. Well-intended criticism should not be frowned upon, but encouraged. Along with everything else that is human, the courts are likely to err, and criticism is the great corrective of judicial as well as of other error. There is no good and sufficient reason why substantially the same law should be held consistent with "the due process" clause of the constitution of one state and inconsistent with the same clause in the constitution of another state, especially when the law is more urgently needed in the latter and when the Supreme Court upholds its constitutionality. The unqualified manner in which a large portion of the press denounced the clause on the judiciary in the democratic platform of 1896 was most unfortunate. The worst enemies of the courts are those unqualifiedly opposed to calling them to account. Such an attitude suggests that our judicial system will not stand the light of criticism, tends to bring it under suspicion and to undermine its authority. To dam up the free expression of grievances real or imaginary forces people to nurse their wrongs, prevents the orderly correction of injustice, and creates the conditions of a social conflagration.

[27] William L. Ransom, *op. cit.*, pp. 132–133.

# THE QUESTION OF AGRICULTURAL POPULATION

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IN current discussions of country life there seems to be the implication if not the direct claim that the urban population of the nation is relatively too large as compared with country population. Regret is general because boys and girls leave the farm. The steady regression of percentage of rural as compared with urban population in the decades of our national life gives rise to apprehension. It is held as a disquieting fact that so many agricultural counties—230 by the last census—should show an absolute decline in population, while the growth of cities is phenomenal.

There are no doubt many reasons for the sentiment in favor of a larger agricultural population. We have not yet come to believe in the city as a normal mode of life. When the older people of the United States were young the country took precedence over the city, and the experiences of childhood passed on the farm perhaps affect the point of view at present. The sentimental claims of agricultural life no doubt color our economics. The sentiment, too, for a return to nature, recrudescing periodically with Horace, Rousseau, Emerson, Thoreau, and John Burroughs, and always deep in the nature of man, fallaciously carries with it the inference that the agricultural population should be relatively large. Of course, the desire for living close to nature has no connection with the economic question of how large the actual agricultural population should be.

But among the most active causes of interest in agricultural population is the high retail price of food. The products of the farm reach the consumer at high expense. It matters little to the consumer where the increase of cost attaches, so long as he must pay prices which by comparison with those formerly prevailing seem to be those of famine. There is perhaps a lurking feeling that farm products should not cost much. The time was when to help oneself to fruit from the farmer's trees or invade his vegetable garden bore not the slightest resemblance to larceny—it simply showed a confidence in the philanthropic nature of farming. Things were "free" in the country, though no one, of course, would feel free to carry off a peck of lead pencils from a stationer's or half a bushel of rubber balls from a toy store.

Let us admit the acceptability of cheaper food. How does this affect the question of agricultural population? Does it follow that because food is expensive there should be more farmers? It is found that lima beans retailing in New York City for $4.80 a bushel paid the Long Island farmer who grew them 30 cents a bushel, after making allowance for commission and freight charges. Surely the additional charges on food due to the middleman is no justification for more men to engage in agriculture. Food is still cheap as it leaves the hands of the farmer.

Let us also admit the prevalence of unscientific and wasteful methods of agriculture. There is certainly great need of reforming the practise of farming. The abuses of agriculture are so patent, such as the keeping of inferior stock, the neglect of farm machinery in the west, the impoverishment of the soil due to lack of proper rotation of crops and fertilizing, and improper methods of tillage, that public interest has been aroused. But this aspect of agriculture surely does not warrant the cry of back to the land, but rather a demand for more intelligence in production. Indeed, with more scientific farming fewer men would be needed on the land. The increased use of machinery on the farm has already decimated the rural population. It by no means follows from the high cost of farm products at retail or from the evident waste from poor agricultural methods that a relative increase in agricultural population is desirable.

The need of clearness in regard to the real basis for the size of agricultural as compared with urban population is evident. There must be some rather definite relationship between country and city populations, lying deeper than passing modes of thought or superficial enthusiasms. Is there not a question as to whether there should be a relatively larger agricultural population? May it not even be disastrous eventually for migration countrywards to be stimulated? That there are acute questions in regard to the farm and life in country must be admitted. But the very common assumption that there should be a movement back to the farm, in the sense of numbers, may be open to doubt.

May we not first of all dismiss the idea that people leave the farm primarily because of preference for city life? As a matter of fact the country makes an immense appeal to millions of people who are forced to live in cities to earn a living. The hardships of the farm, such as are not forms of poverty, would hardly deter people from living on farms. Hardships did not prevent the "forty-niners" from seeking gold, nor do hardships of weather, exposure, or isolation successfully oppose the seeking of wealth in any field.

It may perhaps be safely argued that the number of persons engaged in any occupation bears a very close relation to the economic attractions offered. If the ease of securing gainful employment is greater in city than in country nothing will prevent a transfer of population. If a farmer with a capital of $4,000 can by moving to town get as much for his labor as a drayman as he formerly got for his labor and capital, he is likely to move to town and put his money at interest, thus increasing his annual income. A young man in the country after gaining an amount of schooling is ready to offer his services for sale. Where is the best market? In the majority of cases he finds that it is in the city. He follows the job.

The steady and rapid drift of agricultural population to cities implies the economic dominance of the occupations of cities. If the population of cities tends to outstrip that of the country, it is evident that wealth is relatively increasing rapidly in cities. Where wealth is there will men gather. No amount of exhortation or solicitation will avail to turn the tide countryward if the wealth pull is toward the city.

But is the economic dominance of the city and the suction of life out of the agricultural areas normal and legitimate or unnatural and sinister? Should we make up our minds to the steady continuance of the cityward movement or set our faces against it? What is the rationale of the matter?

In this connection perhaps the truest light comes from noting a somewhat overlooked fact in regard to modern tendencies in consumption. The things we buy are increasingly those of the city rather than of the farm. A smaller and smaller percentage of income is being spent for forms of goods associated with the farm. As standards of living improve there arises an ever-increasing demand for things the farm has little or nothing to do with, such as professional services, classes of manufactured articles, and recreations.

Suppose, for example, that a family with an income of $2,000 suddenly acquired a $4,000 income. Would the farm receive a larger sum, provided the whole income were spent on living? Would this family buy more eggs, potatoes or apples? Possibly a little more. But would not practically all of the increase of income go for the goods of the city? Suppose a man inherited a million dollars and set out to spend it. How much more would he spend in which the farmer would directly share? Even in hypothetical expenditures for rare wines and fifty-cent cigars the grape grower and the tobacco raiser would share but faintly, for manufacturing and distributing processes would absorb the lion's share of the retail price. And as for automobiles, grand pianos, works of art, travel and operations for appendicitis, city occupations would be the almost exclusive beneficiaries.

With increase of purchasing power the prosperous consumer wants but little if any more of direct farm products, while his desires for other values soar. Agricultural products cater to a low range of fixed wants, while non-agricultural goods satisfy wants which are ever in advance of power to purchase and are virtually without limit. The wants satisfied by agricultural products may be thought of as occupying the space between parallel lines, while the wants satisfied by non-agricultural goods, the product of cities, occupy the space between the indefinitely extended sides of an acute angle.

Hence it is that the future belongs to the non-agricultural sphere, for we may assume an indefinitely rising standard of living among all classes. Non-agricultural goods and occupations are bound to increase their lead over straight agriculture commensurately with advancing civilization, which implies the acquirement of more wants of acceptable type. Were man but to feed and sleep the case were different. Inasmuch as population, urban and rural, must be correlated with the production of goods and corresponding income there is reason for believing that the drift toward the occupations at present largely local to cities must be accepted as a final decree of civilization.

It is true, of course, that the farm is the source of many materials which enter into manufactured articles. But where manufacturing processes are superimposed on agricultural production, the selling price of the final product is rarely divided at all equally between the farm and the factory. A farmer sells a hide for about the sum received by the department store for a purse. Whole wheat breakfast foods return the farmer one cent to 11½ cents for other industries. The wool in a suit of clothes returns the grower $1.84, while the finished suit is sold by the tailor for $50. Wherever finishing processes are applied to raw farm products, whether in the case of Saratoga chips or peanut candy, the division of the final selling price is usually overwhelmingly in favor of the non-agricultural industries.

Unquestionably in many cases the division is unfair. The farmer does not get enough and other participators get too much. Considering the unflagging labor for long hours on the farm and the almost desperate struggle waged on many a farm for income, it is beyond doubt that the exploitation of the farmer has been equaled by nothing except the factory system at its worst or the institution of slavery. When one considers that a real cabbage must be sold by the farmer for cents while an artificial rose will sell for dollars the irony of the farmer's position is manifest. A steer sold by the farmer for $80 is served in fashionable restaurants for $2,500. The current division of values between farm and city industries is one of the monstrosities of civilization, the correction of which would steady the flow of population to cities, perhaps even suddenly check it for a period, but in view of the nature of human wants the ultimate dominance of city occupations can not be gainsaid.

Assuming a tendency toward correlation between agricultural and urban wealth and population, it is interesting to note the relative standing of city and country at the present time. Is the national population divided between country and city in proportion to the division of wealth?

While the last census gives the rural population as 53.7 per cent. of the national population, the actual number of residents on farms is much less. In the rural population as reported by the census of 1910 is included the population of towns and villages having less than 2,500 inhabitants. The actual agricultural population is about one third of the national population. In 1910 35.3 per cent. of all persons reported as having gainful occupations were engaged in agriculture.

With one third of the national population engaged in agriculture, we have only to compare agricultural with other production to reach certain inevitable conclusions. Were a parity of wealth distribution maintained between city and county, evidently the income to agriculture should be about equal to one third of the total social production. But is this the case, and if not what deductions may be drawn?

The census of 1910 gives the total value of manufactured articles for the United States for the year 1909 as (in round numbers) 21 billion dollars. The total agricultural production for the same year was 8½ billion dollars. So far the division of social income seems to correspond fairly equitably with division of population. But there is more to be said. When the 21 billion dollars' worth of manufactured articles reaches the consumer the value has been augmented by transportation, advertising and sellers' charges by at least 50 per cent. above factory prices. Probably this estimate is absurdly low. But at the lowest estimate the 21 billion dollars has become 30½ billion, as against the 8½ billion of agricultural production. But wait, the 8½ billion dollars' worth of agricultural products, on its way to the consumer, doubles in value, according to results of investigations of the United States Department of Agriculture. This means that while the farm receives 8½ billion dollars the city occupations based upon agriculture obtain another 8½ billion dollars. Adding this sum to the income of city occupations heretofore given and we have a grand total of 39 billion dollars income for the city as against 8½ billion for the farm. The addition of professional incomes, local to the city, would increase the total by a very large amount. But at the lowest figures the city's share in the division of productional values is 82 per cent. to but 18 per cent. for the farm. Were population apportioned between agriculture and the city on this basis there should be over 75 million people in cities and less than 17 millions on farms. On this basis there are now millions more people in agricultural districts than agricultural, as compared with urban, income warrants.

Why this remarkable relatively large population on farms? Historical reasons might be cited, but perhaps there are two main causes—a phenomenally low standard of living in agricultural areas, and low per capita wealth production. It is evident that present agricultural income can maintain only a standard of living that is on the whole far below the average prevailing in cities. On the other hand, with a third of the national population producing less than 18 per cent. of the social income it must be inferred that productional methods on the farm are much in arrears of those employed in city occupations. There remains, of course, the speculation as to the extent to which urban interests "farm the farmer." Feeble selling methods on the part of the farmer result in low prices for his goods and affect the total and per capita agricultural production as given in census reports. But even with allowance made for the superior profit-taking facilities of city occupations, it would seem beyond question that per capita production in the country is relatively low.

Evidently if more people enter farming, other things equal, the prices received by the farmer will fall due to overproduction and a still lower standard of living result. If more scientific methods of farming are employed, thus increasing agricultural production, prices will tend to fall unless there is an exodus of farmers or selling organizations among farmers to hold prices up. With a higher percentage of population going into farming and with more scientific methods the glut of farm products would be severe, unless relief were found in regulating the quantity of farm products raised for purposes of maintaining prices. The limited physical capacity of society to consume farm products is a fact to be taken into account.

Even if the prices of city commodities were greatly decreased and the prices of agricultural products increased, while the income to agriculture would warrant a higher percentage of population in the country, the absolute amount of agricultural products consumed by society would remain about the same for a given national population, assuming that no scarcity of agricultural products already existed. In the event of larger income to agriculture a larger relative population is conceivable only on the assumption that agricultural production remains about the same, possibly through the shortening of hours of labor by which overproduction would be avoided.

In response to economic laws the drift to cities may be expected to continue indefinitely. We must accept the fact that agriculture is not by any means the dominant occupation, but is relatively decreasing in importance, its logical precedence in the creation of values of course being conceded. But it would be unreasonable to urge a larger relative agricultural population without simultaneously urging organization among farmers to regulate production or to hold prices to a level which would enable them to approximate the standard of living characteristic of cities, unless cheap farmers are desired as well as cheap food. The arguments for a relatively larger agricultural production should not be *ex parte,* for such would prove the farmer's undoing if not refuted by protective efforts among farmers themselves.

# THE EFFECTS OF SCHOOL LIFE UPON THE NUTRITIVE PROCESSES, HEALTH AND THE COMPOSITION OF THE BLOOD

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THE school is a formal agency devised for the purpose of bringing the child into possession of the main body of our social inheritance—the treasures of knowledge and skill laboriously accumulated by many generations of ancestors. When these treasures were few and pertained mostly to the affairs of immediate self-preservation, there was little danger of overburdening the young in the process of their acquisition. The intricacy of present-day civilization, however, is constantly increasing the difficulties which must be met and overcome by all who are not to become playthings of complex social and industrial forces. The period of infancy has not lengthened in proportion to the increased educational demands upon it. The school year has been considerably extended and for the first time in the world's history attendance has been made generally obligatory.

That this situation involves certain physical dangers to the child is self-evident. Indeed, the charge of school overpressure has been made repeatedly for at least half a century, though it is only recently that investigations of scientific character have been directed to the problem. Some of these are here reviewed, in the hope that further researches in this important field may be stimulated.

## THE EFFECTS OF SCHOOL LIFE UPON GROWTH

Schmid-Monnard sought to ascertain the influence of school life upon growth by comparing the growth attained during the seventh year of life by children in school with that attained by children of the same age who had not entered school. The results, as shown in the following table, indicate that school entrance constitutes a shock to the nervous system of the child severe enough to retard growth (15).

| | Growth in Weight Expressed in Kg. | | Growth in Height Expressed in cm. | |
|---|---|---|---|---|
| | Boys | Girls | Boys | Girls |
| Pupils not attending school | 2.2 | 1.9 | 7.4 | 5.6 |
| Pupils attending | 1.5 | 1.6 | 4.2 | 4.5 |
| Difference in favor of former | .7 | .3 | 3.2 | 1.1 |

Engelsperger and Ziegler (4) measured about 500 children, five to six years of age on entering school and again two months later, and found that 20 per cent. had lost weight. This appears significant in view of the fact that the early fall is normally the season of most rapid growth in weight. The retarding effect was most marked in the youngest pupils, those under six years of age. The authors conclude that entrance before the age of six years should not be permitted and that in many cases it ought to be postponed until seven or eight.

Quirsfeld (14) followed the growth of 1,014 children through the first four years of school life and found that 46 per cent. failed to gain weight during the entire first school year, while 21 per cent. showed an actual loss. The number failing to gain during the second year was only 10 per cent., the third year 8 per cent. and the fourth year about 6 per cent.

## The Effects of Prolonged Mental Strain upon the Nutritional Processes and the Composition of the Blood

One of the evils most often blamed for school overpressure is the formal examination. In 1896, Serafani found that examinations caused a marked reduction in the amount of nourishment taken by university students, and a corresponding decrease of weight. His conclusion was to the effect that prolonged examinations tend to bring about a condition of the nervous system resembling that characteristic of persons who are chronically neurasthenic.

Ignatieff (8) made a study of the physical effects of examinations on 242 pupils, ten to sixteen years of age, in a Moscow military school. The pupils were weighed just before they began preparation for the examinations, again at the close of the examinations, and finally after the close of the ensuing 3½ months of vacation. Comparing the second weighing with the first, Ignatieff found that 79 per cent. had lost weight, that about 11 per cent. had not changed and that only 10 per cent. had made any gain. Since the examination and the preparation for it extended over a period from one to two months, and since the pupils were at an age when growth from month to month is normally very rapid, all ought to have shown a gain. As it was, those of the lowest grade lost on an average 2 per cent. of their weight and those of the highest classes over 3 per cent. Quite different is the result when we compare the weight records before vacation with those after vacation, for here we find loss of weight with only 4.6 per cent. and gain with 90 per cent. For 13 pupils, however, the extended vacation was not sufficient to make up the loss of weight suffered during the strenuous pre-vacation period. Ignatieff concludes that in its physical effects the examination is comparable to a severe illness, and that a mental strain severe enough to cause such profound alterations in metabolism could hardly fail to affect unfavorably that organ most concerned in the overpressure—the brain itself.

Binet and Schuyten (2), by carefully weighing the quantities of food consumed by school children in the different months of the school year have been able to show that the child's appetite deteriorates as the school year proceeds. The exact causes of such deterioration are very complex and difficult to disentangle, but the basis, at least, for an explanation is to be found in such investigations as those of W. B. Cannon, Pavlow and others on the physiology of digestion.

Data of this kind lead us to infer that the nervous stimulation involved in excessive mental work produces its injury through such reflex effects as those upon the nutritive processes. Graziani, however, has raised the question whether in addition there may not be unfavorable influences more direct than this explanation assumes. He believes there are two such influences: (*a*) Imperfect oxygenation of the blood and incomplete elimination of carbon dioxide due to the superficial respiration proved by Mosso, Macdonald, Bush, Obici and others to result from application to mental tasks; and (*b*) an immediate effect upon the chemical composition of the blood corpuscles due to the accumulation of fatigue products resulting from mental work (5).

In order to test the latter theory, Graziani subjected 18 university students and 17 children of ten to twelve years of age to blood tests before and after the preparatory period for school examinations. The tests involved three determinations: the number of red corpuscles, the relative proportion of hemoglobin which they contained, and their power of resistance. In regard to the number of corpuscles, no constant differences were found either with university students or with children. The proportion of hemoglobin, however, showed a decided decrease, amounting to an average of 10 per cent. with the students and to nearly that much with the children. The effect upon the power of resistance of the red corpuscles was much the same as other investigators had shown to result from certain poisons. Graziani, therefore, concludes that in all probability mental work produces a toxin which brings about an immediate change in the chemical and functional properties of the blood.

To try this theory still further he subjected himself and a twelve-year-old boy to the same kind of blood examinations, except that in this experiment the blood tests were separated only by a number of hours of strenuous mental work instead of by many weeks, as was the case in the earlier experiment. Here, again, the decrease of homoglobin was marked, amounting on an average to 7.5 per cent. with Graziani himself and to 8 per cent. with the boy. Graziani believes that the underlying cause of school anemia, with its alterations of metabolism and its imperfect oxygenation of the blood, is to be sought in the influence of excessive accumulations of toxic products of fatigue.

Another important study of this type by Helwig (6) corroborates the findings of Graziani. This author made many blood tests upon himself and six other subjects for the purpose of determining the influence of school work, fresh air, rest, marches and lessons of different degrees of difficulty both upon the number of red corpuscles and upon their "degenerative" and "regenerative" processes. The study seems to have been made with the most approved technique and with the greatest regard for scientific accuracy.

The results were rather variable for the corpuscle count, but quite striking as regards the "degenerative" and "regenerative" processes.

As a result of school work the "disintegration-quotient" was increased 29 out of 33 times. The author holds that the study "distinctly" demonstrates that school work not only imposes a strain upon the nervous system, but that it produces a "destructive effect on the blood corpuscles." The numerous tables presented by the author show rather convincingly the influence of the following factors in determining the total condition: (*a*) the difficulty of the school work; (*b*) the length of the work period; (*c*) the frequency of the recitation intervals; (*d*) the amount of exercise and the access to fresh air.

> Arduous mental work produces destructive changes in the blood, while recuperation causes the elimination of waste products and finally a more or less active regeneration of corpuscles.

Observation of the children also showed that external manifestations of fatigue invariably accompany the microscopical phenomena associated with this state.

It was not only from highly sensitive children that these reactions were obtained. The author observed the same phenomena in his own person after long-continued mental strain.

> While a considerable degree of disintegration could be noted in the morning after several weeks of concentrated sedentary work indoors, accompanied by physical depression, lassitude and heaviness, this phenomenon disappeared, together with the subjective symptoms, after a walk of two hours. On another occasion the disintegration quotient increased considerably after four hours incessant work at the microscope prior to taking food and following a prolonged period of close application to research work, but decreased rapidly after two hours devotion to a totally different occupation and lunch taken in the open air.

Rest days showed an immediate effect in a lower disintegration quotient. Long and tiring marches produced only small degenerative values and were followed by rapid regeneration. During a day of mental work disintegration continually increases until late in the afternoon, indicating that this part of the day is least suitable for hard study.

The reverse phenomenon, the improvement which takes place in the composition of the blood as the result of a well-spent summer vacation, has been dealt with experimentally by Borchmann and others (3). Borchmann gave blood tests to 19 boys and 18 girls of Moscow before a two months' "summer colony" outing, and again after their return. The second test revealed an average gain of nearly a million red corpuscles per cubic millimeter of blood and a marked increase of hemoglobin. This is set forth in the following table:

| | Boys. | | Girls. | |
|---|---|---|---|---|
| | Red Corpuscles per Cubic Mm. | Percentage of Hemoglobin | Red Corpuscles per Cubic Mm. | Percentage of Hemoglobin |
| Before vacation.................... | 3,884,000 | 73.1 | 3,760,000 | 69.6 |
| After vacation... ........ ........ | 4,820,000 | 79.2 | 4,480,000 | 78.3 |

Borchmann also tested eight of the girls two months after their return to school and found that in three the number of red corpuscles had still further increased about a quarter-million per cubic millimeter, while in the other five there was a decrease of about two thirds of a million as compared with the second count. But in no case was the condition as unfavorable as before the vacation. The hemoglobin had in some cases decreased 5 per cent. below the second showing, had increased in others, but in all cases it surpassed the pre-vacation record. Lauch had already secured similar results for children of Geneva, and the work of both is strikingly corroborated by numerous blood tests of children who have been transferred from unhygienic conditions of the ordinary class room to the Open Air School.

### The Effects of School Postures on Respiration

The effect of school occupations on the respiration has been studied experimentally by Oker-Blom (13) and by Badaloni (1). The latter secured kymographic records showing the amount of respiration in the upper part of the lungs resulting from different postures assumed in writing. In this way it was determined that the asymmetrical position induced an inflexibility of the upper part of the chest and a decreased depth of respiration in the upper part of the lowered side. Later Binet raised the question whether this may not be compensated by simultaneously increased abdominal breathing. In a second study Badaloni was able to show that no such compensation takes place. His records prove that the asymmetrical position brings a "remarkable decrease" in the expanding capacity of the upper chest. The symmetrical sitting posture, even when the sternum was allowed to touch the desk, showed a far less injurious effect. The author concludes, therefore, that it is the asymmetrical position, rather than the sitting posture *per se,* which is responsible for the school's evil effects upon the lungs. He believes that the school is in this way an important cause of tuberculosis.

In 1911 Oker-Blom (13) reports a similar experimental study of respiration carried on with 25 pupils during different school occupations. The most marked difference found was that between the standing and the sitting respiration. The decrease in total respiration for brief sitting (3 minutes) was about 8 per cent., and for longer periods (12 to 39 minutes), 50 per cent. Interesting differences appeared with different kinds of school work. Knitting, for example, showed an impeding effect upon the respiration of the upper left lung 18 per cent. greater than did reading aloud. In agreement with the results of Badaloni, the greatest impediment to respiration was found in the upper part of the lowered side of the chest. This in turn aggravates the asymmetrical condition and helps to explain why scoliosis tends to run a progressive course. Oker-Blom concludes that all kinds of school activities, including hand-work, must be frequently alternated with change of position and with physical exercises if the danger of scoliosis is to be avoided.

### The School as a Cause of Morbidity

Hertel's pioneer study (7) of the health conditions and work habits of 3,141 boys and 1,211 girls in the secondary schools of Denmark not only revealed what was then regarded as an incredible amount of physical defectiveness, but also demonstrated sufficient correlation of morbidity with years of school attendance and with daily hours of study to forcibly suggest a cause and effect relation. In the first two classes (children eight to ten years) 18.4 per cent. were suffering from one or more chronic defects serious enough to impair health. By the end of the third year the amount had risen to 34 per cent., and by the end of the eighth year, with its average of 8½ hours of daily study, to nearly 50 per cent. Especially significant is the fact that the pupils whose studies were chiefly of scientific nature showed a decidedly lower per cent. of morbidity than obtained among the students of classical courses, which make heavier demands upon strictly intellectual application and afford less opportunity for physical activity. Conditions were even worse among the girls, among whom morbidity rose rapidly from about 30 per cent. in the first two grades to over 60 per cent. by the age of 12 to 16 years. It is difficult to avoid the suspicion that the daily period of study, which increased concomitantly from about seven to about nine hours, may have been to some extent causally related to the increase in morbidity.

The later study of Schmid-Monnard (15) of 5,100 boys and 3,200 girls in the secondary schools of Germany confirmed essentially all the findings of Hertel, revealing in the upper grades a marked increase in frequency of headaches, insomnia and other nervous symptoms.

Roughly speaking, schools with both morning and afternoon sessions showed in the higher grades nearly twice as much morbidity as schools with forenoon sessions only. This is shown in the following table.

| | Morning Session Only. | | Morning and Afternoon Sessions. | |
|---|---|---|---|---|
| | Average, Per Cent. | Maximum, Per Cent. | Average, Per Cent. | Maximum, Per Cent. |
| Total morbidity................. | 25 | 39 | 50 | 74 |
| Nervousness and headaches... | 13 | 28 | 25 | 62 |
| Insomnia.......................... | 1.5 | 5 | 4 | 19 |

Both Hertel and Schmid-Monnard found that the percentage of morbidity rises considerably toward the end of the school year. Mortality, also, slightly increases for a brief period after school entrance, as does also the incidence of infectious diseases.

The most extensive and important single investigation of this kind yet made is that carried out by the Russian Department of Education, the results of which were reported by Khlopine in 1911 (10). This investigation was essentially a sanitary census of all the secondary schools of the Russian empire, carefully and uniformly carried out under the direction of the chief medical officer of schools, and including about 116,000 out of the 139,000 pupils enrolled. Its main purpose was to establish the incidence for age, grade, sex and type of school of the following defects: myopia, spinal curvature, nasal hemorrhages, headaches and nervous troubles.

Khlopine's data show that myopia is much more common in the upper grades than in the lower, in the larger cities than in the smaller, and in western than in eastern Russia. Spinal curvature increases about 50 per cent. between the first and the last school grade. Between the first and the seventh grade headaches double in frequency while nervous troubles increase nearly fivefold. Nasal hemorrhages, which are thought by some to be associated with the circulatory changes in the head which result from the act of reading, were twice as common in the classical schools, with their heavier demands for reading, as in the technical schools.

We can not here enter into a critical discussion of the above investigations. It is well to emphasize, however, that such studies have to deal with exceedingly complex factors whose respective influences are hard to separate. At the same time, the problems are very challenging to the biologist and physiologist as well as to the school hygienist, and are probably capable of being refined in such a way as to yield more positive results than we have yet had on this aspect of human efficiency.

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# THE PHYSICAL BEETHOVEN

By Dr. JAMES FREDERICK ROGERS

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THE study of the parentage of Beethoven should cause the over-zealous eugenist to pause and ponder whether we as yet have sufficient knowledge of the conditions governing heredity for the passing of any save the most tentative laws toward the regulation of lives to be.

Beethoven's mother was consumptive, his father a sot, and yet, though his immediate ancestry promised so little, the great musician was a giant in bodily force, a marvel of sober mental power in his art and a profound thinker along other lines; tender and self-sacrificing in his family relations, and of lofty moral sentiment and practise. Erratic he undoubtedly was, but largely from the stress and distress of a hyper-sensitive organization, produced by his deafness and other bodily ailments.

Little is known of the ancestry of Beethoven. His grandfather, who seems to have been a worthy man, and well-to-do, was apparently of good physique and in excellent health. Besides being a musician he carried on a small wine business. His wife was not so steady. The wine shop was too great a temptation for her. She fell into intemperate ways to such an extent that it was found necessary to confine her in a convent. Their only surviving child came easily by his mother's bad habits, for "he was given to tasting wine from a very early age." His illustrious son often rescued him from the clutches of the police and helped him home, always with the utmost tenderness. He was never known to utter a bitter word about his father, and he resented any uncharitableness toward him on the part of others. His father lived until Beethoven was twenty-two. His mother, who is described as a pretty and slender woman, died, after a long illness of consumption, when Ludwig was seventeen.

The boy Beethoven was a lively little fellow, but more reserved and less boisterous than most at his age. He evidently had a goodly fund of animal spirits for, like all healthy children, he had a great dislike for sitting still, and it was necessary to drive him to the piano if any studying was to be done. His unfortunate father, hoping to produce a profitable prodigy—possibly another Mozart—began his lessons by the time he was four years old and kept him hard at work at them. Friends of his youth told of how they had seen the boy standing on a stool before the piano, crying, as he practised. Pfeiffer, a teacher who lived with the family, after coming home with the father late at night from the tavern, frequently took young Ludwig out of bed, and kept him practising until morning.

In later youth, as events in the family produced their influence and as his mind began to go out into the realm of the spirit, he became quiet and reserved. He is described as a boy, as being short in stature, but muscular, "awkward, and with a snub nose."

With many conditions, including poverty, to depress his soul, and with apparently little to aid in his bodily unfolding, he nevertheless developed into a tremendously vigorous man—"the very image of strength," with a constitution that defied the attacks of disease and the influence of mental depression, for fifty-seven years."

As early as his seventeenth year he mentions being "troubled with asthma," which he feared would "lead to consumption." Very naturally he thought of such a termination since his mother died in this year. "I also suffer from melancholy which for me is almost as great an evil as my illness itself." Evidently it was his nature to be brave and buoyant, and it was this attitude toward life which constantly finds expression in his music. There is nothing sickly in his art.

But asthma was but the least of the dark demons of disease that came to dwell with him. At about the same time he had already begun to have symptoms of a depressing malady of the digestive organs which finally brought about his dissolution.

Worst of all, and before he was twenty-eight, there came the affection of the ears which speedily brought about deafness, the most trying of all his ailments. Already at this age this disease had so progressed that he was in mortal dread lest his infirmity be observed. After three more years he "found himself unable to hear the pipe of a peasant played at a short distance in the open air." His genius was fairly unfolding itself and was receiving the recognition of his contemporaries. And to be rapidly growing deaf! It is not to be wondered at that his melancholy became profound, and that only deep religious conviction and his ability to live in the glorious realm of the imagination, saved him from taking his own life.

Many doctors and more cures were tried for his deafness, but with no avail. In 1802 he writes: "For the last two years I have avoided all society, for it is impossible for me to say to people, 'I am deaf.'"

In 1802 his sense of depression reached its lowest during an acute illness, and his despair found utterance in the letter to his brothers, which is known as "The Will." He bewailed his exile by his deafness from the diversions of society which he had so loved; and lamented his seeming moroseness which this condition had brought about. The contemplation of this affliction, he writes to his brothers, "brought me to the brink of despair, and had well nigh made me put an end to my life. . . . Recommend virtue to your children; that alone—not wealth—can give happiness. I speak from experience. It was this that upheld me even in affliction; it is owing to this and my art that I did not terminate my life by suicide."

From this time he seems to have become reconciled to the worst. There is in his letters little mention of illness for the next twelve years, and he was apparently in robust health. Nevertheless, disease was his constant companion and his deafness steadily progressed. In 1805 he was able to judge severely of the musical expression in the rehearsal of his opera. In 1814 he played his B flat trio. From 1816 to 1818 he used an ear trumpet. He continued to conduct his works, but in 1822 nearly brought the performance to ruin, although he was able to detect that the soprano was not singing in tune. Later in the same year he again attempted to conduct, but with such ill success that he did not try it again. This event meant so much to him that it marked another epoch in his life. From this time he was able to communicate with his friends only by writing.

The loss of his hearing undoubtedly had a most depressing effect upon his general health, and besides he was "constantly on bad terms with his digestive organs." His magnificent constitution was, however, as yet hardly touched by his continued ailments. In his collected letters there are from 1816 numerous notes to Archduke Rudolph begging ill health in apology for failure to keep his engagements as tutor to his highness. These are perhaps not to be taken so seriously as they sound, since he took little pleasure in his tutorship, though they indicate his continuous ailments.

In 1817 there are, however, letters to friends telling of his more serious illness. In June he wrote: "I caught a very severe cold which forced me to keep my bed for a long time and many months passed before I could venture out." After much drugging with powders and tinctures he is taking the baths at Heiligenstadt. He feels "that for several years [his] health has been steadily getting worse."

In 1818–1819 his health was much better and his devotion to the composition of his mass was extraordinary. Never had he been known to be so entirely abstracted from external things. It is to these years that the Ninth Symphony and the great Mass in D belong.

In 1821 he was laid up with a severe attack of rheumatism. He was at Baden for a part of the time and for some two years he was quite ill.

In February, 1822, he writes: "Last night I was again attacked by *ear ache* from which I generally suffer at this season of the year."

From 1823 on he was more or less continuously ill and under constant treatment by baths and drugs, always hopeful, always finally worse.

In October, 1826, Beethoven, with his miserable nephew, visited Johann Beethoven at Gneixendorf. This niggardly man denied his sick brother a fire in his room, although the weather became severe, and the food he served him was not suited to Beethoven's disturbed digestion. They quarreled over the affairs of the nephew, and the composer packed his things on December 2 for a journey back to Vienna.

"It was biting weather, and even the winter sun seemed permanently hidden. A closed vehicle was consequently indispensable for a fifty miles' journey; the brother would not lend his, so with great misgivings Beethoven hazarded an open conveyance—a milk cart, it is supposed,—'the most wretched vehicle of hell' as the composer described it. . . . Beethoven, though only clad in summer clothing, resolutely faced all." It was a two days' journey and it cost him his life.

He took to his bed. Not only were his old ailments aggravated, but inflammation of the lungs set in. His nephew neglected to call a physician and none came to see him until three days after his return. Dropsy, the last symptom of his old abdominal ailment, appeared and on December 18 he had to be tapped. Again on January 8 and 28 the fluid had to be withdrawn. "Better water from my body than from my pen," he is said to have remarked. Malfatti, a former physician, was called, and under his care he improved, but only for a time. "His long, painfully long, end was now beginning. His constitution, powerful as that of a giant, blocked the gates against death for nearly three months." The end came on March 26, 1827, at the age of fifty-seven.

The physical Beethoven was a most impressive figure. He was not tall—was in fact, short,—not over five feet five inches, but with broad shoulders, and very firmly built. Siegfried said that "in that limited space was concentrated the pluck of twenty battalions." His head was large, with profuse black hair thrown backward and upward from a grand forehead; he had great breadth of jaw and somewhat protruding lips. His clean-shaven face was pock-marked from early youth, and browned and burned by wind and sun; his eyes, large and jet black, were full of the fire of genius, and were often remarkably bright and peculiarly piercing; his teeth were beautifully white and regular. His hands were thick and dumpy, with short, untapered fingers; his feet, small and graceful. On the whole his was not a handsome figure, "but the ugly pock-marked man with the piercing eye, was possessed of a power and beauty more attractive than mere physical charm." One person described him as "power personified," and another thought of him as a Jupiter.

Julius Benedict, who saw him in 1822, wrote: "Who could ever forget those striking features? The lofty vaulted forehead with thick gray and white hair encircling it in the most picturesque disorder, that square lion's nose, that broad chin, that noble and soft mouth; . . . his thick-set Cyclopean figure told of a powerful frame."

His voice varied. "When quite himself it was light in tone, and singularly affecting; but when forced, as it so often was, on occasions of anger and temper, it became very rough and far from sympathetic."

In his later years, depressed by sickness or wrapped in his music, he grew careless as to his personal appearance, and even one of his admirers—the Countess Gallenberg—noticed that "he was meanly dressed, and very ugly to look at, but full of nobility and fine feeling and highly cultivated."

He was very regular about early rising, work and exercise, but beyond this he was singularly erratic in his habits. He was up with the sun, summer and winter, and worked from breakfast to dinner at two or three p. m. Dinner over, he immediately went, rain or shine, hot or cold, for his half walk, half run, into the country, or, at Vienna, about the ramparts. In his solitary life "Nature became to him a mother, sister and sweetheart." Neate said that he "never met any one who so delighted in nature or so thoroughly enjoyed flowers or clouds or any other natural object." "He was out of doors for hours together, wandering in the woods or sitting in the fork of a favorite tree." To Beethoven "every tree seemed Holy, Holy"; he exclaims: "No one loves the country better than I do," and "Oh! the charm of the woods,—who can express it?" It was in communion with nature in fields and woods that his inspiration flowed most freely into his sketch books. He worked as he walked: "As the bee gathers honey from the flowers of the meadows, so Beethoven often collected his most sublime ideas while roaming about in the open fields." He seldom composed in the afternoon or evening.

Schindler tells us that "the use of the bath was as much a necessity to Beethoven as to a Turk, and he was in the habit of making frequent ablutions. When it happened that he did not walk out of doors to collect his ideas, he would not infrequently, in a fit of the most complete abstraction, go to his wash hand-basin and pour several jugs of water on his hands, all the while humming and roaring, for sing he could not. . . . Then he would seat himself at his table and write; and afterwards get up again to the wash basin, and dabble and hum as before." On more than one occasion the water went through the floor and trickled from the ceiling below, with the consequence that the master was forced to move to other quarters.

Like most great men, the matter of food and eating was of little moment to Beethoven. It was sufficient for him if he derived from his meals ample energy for his work. "Wherefore so many dishes?" he exclaimed on one occasion. "Man stands but little above other animals if his chief enjoyments are limited to the table." While absorbed in the composition of the Mass in D, he worked like one possessed, and at least once was so absorbed that he went without eating for twenty-four hours, and he "looked as if he had gone through a struggle of life and death." His irregular meals of badly prepared food, hastily devoured, would have damaged more perfect organs of digestion than those of Beethoven.

For breakfast he usually had coffee, which, like Brahms, he often prepared himself. He allowed sixty beans to a cup, and made it a rule, when he had company, of counting the beans for each cup. At dinner his favorite dish was macaroni with Parmesan cheese. He was very fond of fish and on Friday always had fish and potatoes. A plate of soup or some left-over answered his purpose for supper. His favorite beverage was fresh spring water, which he took in large quantities. He was no judge of wines and is said to have injured his stomach by drinking adulterated kinds. He liked a good glass of beer and a pipe of tobacco in the evening.

If erratic in his habits, it was chiefly Beethoven who suffered the consequences. He was singularly pure in his life,—but only from such loftiness of character could come such music.

The physical Beethoven is reflected in his art—all but his ailments and illnesses. These never touched his spirit. He was a Titan and his work was titanesque. Not only is there nothing morbid in his music, but it contains more of humor than that of any composer. Beethoven remained physically robust to the last, notwithstanding his continual fight with disease. His afflictions only served to drive his soul farther into the realms of the ideal. His most profound utterances were poured forth in his last years, and, even in his last illness, "his overflow of fancy was indescribable and his imagination showed an elasticity which his friends had noticed but seldom when he was in health."

The examination of the wreck of that most powerful bodily machine showed the auditory nerves shriveled and degenerated, the liver, the source of his digestive disturbances, shrunken to half its normal size, and there were other signs of chronic disease, which, on slight grounds, has been attributed to syphilis. The convolutions of the brain were more numerous and twice as deep as usual.

So much for the Beethoven laid away at Bonn in 1827. The Beethoven of the Heroic Symphony—of the Leonore and of the Mass in D—is even more alive in all his inspiring strength and beauty than he was a century ago.

# THE WORLD VERSUS MATTER

By WM. E. RITTER

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JUDGING from what one hears and reads, there is a great variety of opinion as to what sort of a thing the world in which we live really is. Indeed, so diverse are these opinions that one can hardly help wondering if we all do actually live in the same world.

A correspondent, unknown to me personally, writes that after having lived eighty years, he finds with every passing year and day the world becoming to him more marvelous and interesting; and this as the culmination of a career which seems to have been particularly well filled with affairs at arms, in business and of the intellect.

An artist friend is so laid hold upon by the glories of color and form that abound in each spot, new or old, in which she finds herself, that nothing could convince her that the essential frame and substance of the world is not beauty. Shift the motive of this type of person slightly, from that of delineative art to that of the discursive interpretation of nature, and you have the Jefferies, the Muirs and the Burroughs—the emotional naturalists.

Through many centuries and lands there has been the religious humanist who has taken to his soul the words "Behold, I have given you every herb-yielding seed, which is upon the face of all the earth, and every tree in which is the fruit of a tree yielding seed," and has rejoiced as he has repeated "And God saw everything that he had made, and behold, it was very good."

But alongside the radiant-faced religious humanist there has stood the sour-visaged religious ascetic, muttering:

Hence lying world, with all thy care,
With all thy show of good and fair,
Of beautiful or great!
Stand with thy slighted charms aloof,
Nor dare invade my peaceful roof,
Nor trouble my retreat.

And there has been, too, the sweet-voiced religious ascetic, saying:

Ah, love, let us be true
To each other! for the world which seems

To lie before us like a land of dreams,
So various, so beautiful, so new,
Hath really neither joy, nor love, nor light,
Nor certitude, nor peace, nor help for pain.

The outward gentleman who is an inward voluptuary, confides to you upon occasion that he is a "man of the world," and with the slightest encouragement he will let you know what "the world" is viewed from his standpoint.

The subjective idealist speaks without a qualification or misgiving about "my world," "your world," "his world"—how we, he and you and I create these several worlds.

"Nature is in reality a tapestry of which we see the reverse side. This is why we try to turn it," says a distinguished French literary critic.

A fact about these various worlds which comes out in bold relief when we place them alongside one another is the way they contradict, in some instances quite annihilate, one another. Perhaps the crowning instance of mutually annihilative "worlds" is the "all is flux" world of the Hereclitian philosophy, and the "no new thing under the sun" world of Ecclesiastes. And if any one is disposed to think this Greek-Hebrew world muddle is too ancient and outworn to be significant for us moderns, let him recall, on the one hand, the energeticers, to use a term that has gained some currency for designating a number of men high-stationed in the science of the present moment; and, on the other hand, those speculators who largely stake their scientific faith on a motionless ether.

The world surely does "speak a various language" to different persons. This can not be doubted. And there is much to justify the assertion of a German writer on esthetics that "Die Natur ist jedem ein anderes" (Nature is something different to every person). "Dem Kinde [ist es] kindlich, dem Gotte göttlich" (To the child it is childish, to the God, divine).

But is it really true that nature—the world—is through and through different to each person? Does each one create and possess his own world, and that in such fashion that these worlds have not in deepest essence, identical elements of uncompromising objectivity? Were I to attempt to answer this question to-night in terms that would fit well into the scheme of office furniture, so to speak, of either the professional scientist or the professional philosopher, I should soon empty this room, at any rate, if the company were to be more truthful than courteous in expressing its feelings as to the properties of such an occasion as this.

So what I say toward an answer to the query shall not be in the rôle of either scientist or philosopher, but rather that of the humble naturalist; or, as I prefer, natural historian. This means a descent from the dizzy perch of "the world" to the humble, particular things of which the world is composed. Or, expressed in the vernacular, it means "coming down to brass tacks." Exactly! Imagine, if you will, a representative emotional naturalist, a representative realist in art, a representative humanitarian religionist, a representative ascetic religionist, a representative "man of the world," a representative subjective idealist, and representatives of as many other types of world-viewing as you like, each one taking his turn in stepping, barefoot, on the upturned point of a brass tack. Is there anything in the result upon which they all agree? Note particularly that I do not ask, "Is there anything in the result about which they, or some of them, disagree?" Almost certainly there will be disagreement as to some of the details of the result; but these disagreements will not invalidate nor make meaningless the points on which they do agree. Very well, then, as to this experiment the general conclusion is that brass tacks are neither totally different nor absolutely alike, as interpreted by these several observers.

You will not miss my point: This rosebush in the front yard, that house across the street—is there the slightest disagreement among us, no matter how divergent our points of view, my ten-year-old boy friend, my man-of-the-world friend, my subjective-idealist friend, my artist friend, my Christian science friend, and all the rest, that this *is* a *rosebush,* and that that *is* a *house?* Does any one hedge or qualify in answering? Is or is not this a big rock on which we sit, an automobile in which we ride? Imagine yourselves, each one of you, under demand to choose in just three seconds between an unqualified "yes" and an unqualified "no" as an answer, the demand being backed up by a Winchester rifle leveled at your head. The first point to be gained in this is to see whether you will or will not *make the choice,* not to find what the choice will be. Either the "yes" or the "no" will save your life. What the demander is after is to find, first of all, whether or not you *can choose* instantly, when the issue is one of life or death. Having decided that, the question of what the choice is, is greatly interesting. Do you doubt that you would choose? And do you doubt that the "ayes would have it" unanimously? There is then, is there not, something about the world on which we can all agree? Is there not, in fact, a great deal about it on which we can agree when we come down to "brass tacks"; that is when common sense is appealed to, and life or death the issue?

I am speaking under the auspices of a scientific society to a more or less general audience. The occasion seems fitting, therefore, to raise the question as to what science is doing and may do toward finding what is solid in the world for all mankind—ground on which all may stand with equal unobstructedness of view for looking at the vast complex of things we name "nature" or "the world." The way in which I have raised the question forecasts not only my belief that science has done and is doing very much in this direction, but also something of the methods by which I conceive this greatly-to-be-desired good may be still farther attained.

Do you remember how Christian on his journey to the Celestial City used to get out his roll in times of sore perplexity and read what was written therein? The Roll which, according to my doctrine, every successful pilgrim must have easy of access when the trail grows dim, the body weary, and hope and faith weaken while traveling the hard road toward his Fair View of the world, is Common Sense. Notice I do not say such a guide alone would take anybody anywhere. What I mean is that I do not believe anybody's Fair View is truly fair unless he does read in this Roll over and over again. And one of the things I want to hammer home to-night is that Section I. of the Roll is natural history—unostentatious, old-fashioned description, designation and classification of the myriads of objects by which we are surrounded: men and dogs, wagons and cows, trees and disease germs, clouds, rivers and birds, stars and mosquitoes, windmills and cherry blossoms, and all the rest.

I am particularly solicitous about this Section I. of the Roll because generous as is my recognition of what science is doing to help forward a better world view, and profound as is my faith that it will not, in the long run, be lukewarm or ineffective in this part of its mission, I am unable to be blind to the great neglect of this section in our day by many men of science, particularly those who are cultivating certain compartments of the realm of nature. And negligence in both fact and spirit of this first section (of clear description and designation) unavoidably entails considerable neglect of the whole Roll.

To make sure that my allegory is clear, I explain that it means that, according to my view, there are always currents in the sciences of external nature setting against common sense; and that in our era these seem to be particularly numerous and strong. Always in considerable danger of becoming sophisticated, science is specially open to this peril in an era like the present, when the momentum of its advance is so great that restrictions and criticisms leveled against it from the outside are hardly felt by it at all. It is doubtful if *internal* criticism in any great and well-established realm of knowledge is quite sufficient to insure its complete doctrinal healthfulness.

The particular form of sophistication which science is now suffering and against which pressure from the outside is, I believe, going to compel a reexamination and readjustment, is what is called, indifferently because uncritically, sometimes materialism and sometimes mechanism. A sharp distinction ought, I am sure, to be made between materialism and mechanism. But I shall be true to my earlier promise and spare you a discussion so recondite as would be one that should undertake to establish this distinction.

What I am going to try to do is to show, briefly, that materialism held down to its legitimate meaning and made a general theory of the world is a form of scientific sophistication; and then especially, to insist that natural history is the natural antidote and prophylactic against such sophistication.

A young mathematical physicist, who I hear is highly regarded among his fellow workmen, tells me that one of the "fathers in Israel" of their science declares that physics is bankrupt to-day. Now I should not take this declaration, by itself, very seriously. Of the bankruptcy of science as a whole, and of particular branches of science, we hear rather frequently. But from some of the things this young friend tells me, and from what I gather from other sources—by conversation and the reading I am able to do along the edges of the domain of physics—I am led to suspect that there are conditions within that domain which justify considerable solicitude for the health of that science. My young friend's epigrammatic way of stating the situation is this: All nature reduces itself to matter, all matter to electrons, all electrons to ether, and all ether to a hypothesis.

Only a few days ago I heard a physical chemist making a sharp distinction between what he called the "world of fact," the world of common sense, and as he put it, "the world with which science deals." I submit that if such statements coming from within the portals of the physicochemical realm are to be taken seriously, if science as understood within that realm is not dealing with facts, then indeed are outsiders justified in taking seriously also the ex-cathedra statement about the bankruptcy of this science.

If then there really is cause for solicitude as to the solvency of physics—if it has used its credit (its speculations) well up to the limit of its assets (its facts), how has it come to do this, and how might it get back to a safe business basis?

Should any one question the right of biology, which science I represent, to inquire into the internal affairs of physics, the reply is that biology has heavy investments in physics both as depositor and stockholder, and so has not only the right but the duty to be informed as to physics' solvency or insolvency.

I believe physics and chemistry for years have been and now are violating certain principles fundamental and common to the right interpretation of nature in all its subdivisions. To return to the banking simile, these sciences have, unwittingly and unintentionally, invested their funds in inadequately protected securities. This I understand is a grave charge, and any one who should make it without being able to support it with unquestioned facts and the most painstaking argument ought to be looked upon as either a trifler, a charlatan or a well-intentioned incompetent. Since I do not court being listed under any of these heads I must state, as briefly as possible, the exact nature of the offense which, as I believe, physics has committed. Stated in the most general terms, it is against the natural history mode of viewing nature; or to carry the statement one step farther toward specificity, it consists in a violation of certain essential principles of observation, description, designation and classification which are so obviously the very foundation of the natural historian's "world." Or, expressed still more positively, physics has become over-mathematicized, and has concentrated its gaze too exclusively on a few attributes of what it calls matter, or substance. What I mean by being over-mathematicized is not that mathematics has been applied too widely or exactly to physico-chemical problems, but that the reasonings of pure mathematics, that is, mathematics as a purely subjective process and without reference to its application to objective reality, has been too exclusively relied on in the formulation of general theories. Not sufficient restraint in theorizing has been exercised, in view of the fact that the "probable error" involved in all physical experimentation contains two chances of error, the one wholly manipulative; that is, dependent upon imperfections of apparatus or methods; while the other, and from the present standpoint, far more important chance of error is that of undiscovered factors in the phenomena themselves which are being investigated.

A physiologist of deservedly great distinction has expressed the view that just as "the constitution of matter is the main problem of the physicist, the constitution of living matter is the main problem of the biologist." I want to call attention to the fact that "matter" with its connotations in the above statements is, historically, a poetic fancy; and further that it is merely a convenient symbol or fiction when considered from the standpoint of truly objective or observational science. Glance at the subject historically first. You hardly need be reminded that the conception of matter has come down to us from the ancient Latin poet Lucretius who sets forth his views with sufficient elaboration in his great poem "Concerning the Nature of Things"; and that he in turn got the idea from certain Greek philosopher-poets, more particularly Democritus. While Lucretius undoubtedly had much of the spirit of genuine objective science, no modern who studies his work and reflects on the influence it has had on subsequent literature and philosophy and science should forget for a moment that, as concerns methods and results of actual positive science, it was quite impossible for him to be more than mildly scientific; nor forget that his interests were primarily poetic rather than scientific. What he was aiming to satisfy was not so much man's observational and rational nature as his own emotional nature. His undertaking is well characterized by a recent writer in this way:

Lucretius and the Greeks, in observing universal mutation and the vanity of life, conceived behind appearance a great intelligible process, an evolution in nature.

This process was conceived to have its seat in a single homogeneous substance which was material rather than metaphysical; that is, in brief, was *matter*. The point to be particularly noted is that such a substance must be *behind* appearance; it must be a "hidden background"; it must be invisible. In other words the real world must be an invisible world. The obvious reason for this was that the visible world seemed too transitory and insignificant, and as regards men, too evil and worthless to satisfy the deeper longings of the poet's emotional nature.

Modern materialism has undoubtedly taken on a quite different motive from that which gave it birth, for no one would contend for a moment that the materialistic conception of the world in our day is primarily poetic. Its design is unquestionably rational and logical rather than emotional. Viewed historically this poetic motive of materialism has never met the needs in a large and general way, of the emotional side of human nature. The great epochal outbursts of poetic genius throughout the ages have been in one form or another quite the opposite of materialistic. The Dantes and Petrarchs, and Chaucers and Spensers, the Miltons and Shakespeares, and Goethes and Brownings, have been men with a strongly ideal or spiritual quality. The poets who by touching the hearts of men mightily have become their universal spokesmen have been of very different mould from Lucretius. Taking the facts which history actually presents to us, materialism as a poetic and philosophic motive has not been superlatively great; it has not met the deeper needs of the race.

What we now have to consider is whether modernized, that is to say rationalized, materialism is more successful. You will recall my earlier statement that science, like other fields of human endeavor, is rarely if ever capable of self-criticism to the extent of recasting, with no impetus from the outside, fundamental defects and errors into which it may have fallen. I believe science is now face to face with interests and demands from other quarters than its own that will compel a self-examination of its fundamental processes and conceptions, and then a recognition of what is in reality untenable in its materialistic theory of the world. This pressure, one hardly needs to point out, is being brought to bear from the sides of psychology, philosophy, religion and sociology. Summing up the whole situation, no candid observer can fail to acknowledge that the materialistic tendencies of the last twenty-five or fifty years have had something unmistakably brutish about them as regards the affairs of men. The doctrine of survival of the fittest has surely been of this character, and the so-called economic interpretation of human history and society, based avowedly to a considerable extent on materialistic physical science, has been undeniably hostile to the nobler element of man's nature.

And so it happens that the inevitable reaction is appearing in such phenomena as that which in the political realm of our country is called the progressive spirit, strongly tinctured with religious zeal, and perhaps still more significantly in such mystical manifestations as Christian Science and Theosophy, and the far more soberly wrought out philosophical systems of Bergson and Eucken.

What now, we must inquire, is the fundamental difference between what I am calling the natural history mode of viewing nature and the materialistic mode; and wherein may the former be claimed to be more in accordance with the needs of what is best in man's nature?

The whole problem rests inevitably on the essential processes and composition of our knowledge of the world and can not be touched with the least prospect of success without due attention to what we call the *attributes* of natural bodies.

That these attributes are the common and ultimate ground of both the world itself and of our knowledge of it, is not only demonstrably true, but is truth of such kind that it needs no laborious demonstration except for minds that have become sophisticated by overstraining in trying to answer ill-considered questions. Common sense never strives after a single ultimate, invisible substance, either physical or metaphysical, in the orange *behind* the roundness, yellowness, heaviness, semi-softness, sweetness, juciness, and so on of it. Nor does science ever really demonstrate any such thing, however laboriously it may search for it. What it does accomplish is the resolution or analysis of the orange into innumerable constituent bodies, cells, nuclei, chromosomes and chemical compounds, solid, liquid and gaseous, chemical simples, electrons, et cetera. But—and here is a point of prime importance—each and every one of these bodies or objects has its own peculiar attributes exactly as the original orange had.

Scientific analysis of the objects of nature always runs in a two-fold stream: There are the analyses of the objects into constituent *objects,* and of stages into precedent *stages;* and there are the parallel analyses of these constituent objects into their attributes. Each and every object and grade of objects has its own attributes. These latter and these alone secure for the objects places in our knowledge. Now it so happens that all objects in the world as common experience finds them have many attributes never entirely attainable, so far as we can make out, or recognizable by any single one of our senses. We have an enormous amount of evidence to the effect that all objects of nature whatever possess attributes fitted to our senses of touch and sight at least. We have no well-established experience of any natural object having but a single attribute, or even a group of attributes appropriate to but a single sense.

Such is the indubitable testimony of all common experience and of almost all scientific experience. Right here is one of the strategic points of the whole situation. How trustworthy is the testimony of common experience and of so much of science as supports it in this matter?

Some physicists, how many I do not know, but seemingly a considerable number, do not feel themselves compelled to admit that there are no real objects in the world possessing but a single attribute. As I understand the conception of the electron as a corpuscle ("a little body" you note) of pure, negative electricity—of just electricity and nothing else—of "electricity with no material support" as some writers say, is virtually, though perhaps not admittedly, a natural body with but a single attribute. All ordinary experience is certainly to the effect that electricity is an attribute of *natural bodies* rather than a wholly *independent body*. The innumerable mechanisms all about us, batteries, dynamos, conducting wires, transformers, etc., for producing and handling it, are unequivocal witnesses to the truth of this assertion.

Before it can be admitted that electricity or the "ether of space" or any single entity with but a single attribute under any name whatever, is the real essence and explanation of the whole visible world, we must examine intently what would be involved in such an admission, and also the positive evidence advanced in support of the hypothesis.

First look at the matter for a moment historically or racially as one might say. One of the most significant results of modern anthropological research is the clear demonstration that the mind of primitive man is not clearly differentiated as to the way it recognizes objects in the world by which it is surrounded; that what is subjective and what is objective are very imperfectly separated in the primitive mind as compared with what they are in the mind of civilized man. Indeed the process of becoming civilized may be well characterized by saying that it consists in the gradual sifting out in consciousness of objective, sensible experiences from purely subjective experiences. The chief interest to us about this disentanglement of the human mind from the external world is that it consists, in large part at least, in discovering that what civilized men unquestionably recognize as attributes of natural objects, are held by primitive men to be independent entities on a footing with actual objects, that is, with objects composed of numerous attributes properly combined. The roar of the waterfall, the hoot of the owl, the destroying force of the storm, disease, hunger and the thousand and one other incidents of common life universally recognized by men under civilization as states or conditions of their appropriate objects, are conceived by savages to be independent beings. And it is clear that something of the same sort marks the development of each individual civilized man from earliest childhood to the full consciousness of mature life. In the terminology of biological evolution we have here an instance of the law that individual development or ontogeny repeats in a general way race development or phylogeny. The designation and systematization and organization of sense impressions, on the one hand, and subjective states on the other, which are the very essence of rational life, and which distinguish the civilized man from the savage, and the adult from the child, are found on closer examination to consist fundamentally, as to fully one half at least, in naming and placing and correlating the attributes of natural objects.

Turning now from the racial and the individual development of ordinary rational life, to the development of physical science, we may characterize this development by saying that its whole course has been one of discovery of *new natural bodies* each having its own attributes; and of *new attributes* of old bodies, that is, of bodies already known.

The attributes of bodies, with many for each body, are the very cement and sand and gravel and steel out of which the reinforced concrete edifices of experiential knowledge, both common and scientific, are built up; and any one who comes forward with a hypothesis of nature which in essence declares that some single one of these building materials is all that nature really furnishes so that the edifice of knowledge must get along with only this one, is presenting a daring hypothesis sure enough. If true it must, of course, be accepted; but no one should fail to see that its complete acceptance would mean the complete demolition of the great edifices of common knowledge and physical science as these have been laboriously built up through the centuries, and the erection on their sites of other edifices wholly different in design and construction. Surely the proof in support of so revolutionary a hypothesis must be convincing beyond a shadow of doubt. Is it? For one I am convinced it is not. Were there no other grounds for doubting the electrical theory of matter and so of all nature, a sufficient one is found in the circumstance already alluded to, namely that no physical observation or experiment ever gets rid of the "probable error": and that in this probable error there is always a chance of an unknown factor in the phenomena under investigation.

So I turn again to the natural history way of viewing the world and point out that it is in strict accord with both the historic development of natural knowledge and the fundamental processes of psychic life in that it accepts without cavil the whole range of attributes of natural bodies, demanding only that these be undoubted as to identification. It is only when the natural history attitude and the materialistic attitude toward nature is each viewed in its mode of treating the attributes of natural objects, that the fundamental distinction between the two attitudes comes to view. The natural history attitude is one of unreserved acceptance of the world of fact, one of its greatest concerns being to make sure of what the facts are. It makes no such sharp distinction between fact and truth as materialism tries to make. Facts are the elements of truth much as chemical simples are the elements of chemical compounds. The critical natural-historian recognizes other differences than this between fact and truth but for the present discussion this suffices. All we need to do here is to insist that the cultivators of any domain whatever of natural knowledge who believe they see something in the nature of truth which makes truth's exaltation result in the degradation of fact, are moving over by just so much from the side of true science to that of subjectivism and mysticism, and that they are going *by the road of mathematics* makes no whit of difference so far as concerns the essence of the thing. I raise the question: Has mathematics any legitimate place in dealing with the objective universe beyond that of helping to "visualize" those portions of it too minute or too transparent or delicate for man's unaided senses? In other words, can it render any real service further than that of helping to make the description of nature more full and accurate and serviceable to man?

The natural history motive is not to "get behind" the actual world in the sense in which materialism would do this, but to get more deeply into the actual world—to move more and ever more of the world into the fold of real knowledge.

Scientific or rational materialism no less than poetic materialism is virtually a system of world-repudiation. The natural history standpoint, on the contrary, is the very antithesis of this, and looking at the two systems still from the standpoint of their treatment of the attributes of objects, we are able to see clearly wherein the materialistic standpoint can not possibly meet the needs of man's deeper nature while the natural history standpoint genuinely and unreservedly accepted and understood seems capable of satisfying these needs. In its determination to reduce all things to one or at least a very few simple material substances or forces and so to explain them, materialism of necessity makes the actual world subordinate to, or, as it sometimes says, a manifestation of these deeper essences and in doing this, of course, must subordinate the good there is in the world as well as the bad to these invisible simples; and when we look at what this means in the light of the part that the attributes of bodies play in the make-up of all our knowledge of nature, the real meaning of the statement made some pages back —that there is something genuinely brutish in materialism—becomes obvious. It means that the higher attributes of man's nature are never taken at their face value; they are nothing but manifestations of something lower down and more elemental in the scale of beings. The materialistic philosophy is always a philosophy of "nothing but."

The conclusion of the foremost protagonists in our day of the doctrine of the survival of the fittest and natural selection that the esthetic and religious attributes of men are merely by-products of their survival and sexual instincts, is a conspicuous and remarkable illustration of this truth, and the so-called economic interpretation of human life and society is an illustration from a different angle of the same thing. From the natural history standpoint, on the other hand, there is no more question about the reality and validity and fundamentality of man's higher attributes than of his lower attributes, for it recognizes that the attributes of natural objects, being the very fundamentals of knowledge itself, never are, and seemingly never can be, reduced or explained by referring them to the attributes of other bodies lower in the scale. Its office is not to find something more fundamental and elemental behind attributes either high or low, but to make sure of the validity and generality of all attributes and then get them into a consistent scheme of classification. It, consequently, in the very nature of its procedure, has to fix upon standards of value and importance of attributes. It is in position to accept—nay, more, from the very nature of its undertaking, it must accept men like all other beings and objects in the full range of their natures.

But while I am emphasizing the belief that the natural history way of viewing the world is capable of meeting the deepest needs of man's nature, while the materialistic can not possibly do this, I would wish to make it quite clear that this is not my main motive, as a man of science, in defending the natural history standpoint. Primarily, my position is, that the natural history standpoint is the only one that is in accord with both the historic development of natural knowledge and the fundamental nature of knowledge itself, as well as with the processes by which it is acquired. And I should like to establish the claim that when the scientific interpretation of nature is genuinely sound, as judged by its own undertakings and best interests, it will encourage in every way the fullest and freest development and expression and satisfaction of the whole gamut of man's nature consistent with the healthful coordination of all the independent parts thereof; that is, consistent with the whole of life, individual and social.

And this brings me to the focus of the evening's enterprise: The chance and the duty of natural history to beneficently influence the attitude of people generally toward the world—toward nature, man and society. You will not, I trust, have understood me to mean natural history in any restrictive sense. As I am thinking of it, it includes every aspect of knowledge that aims to find out in the most comprehensive and accurate way possible, the make-up of the world outside our own heads. The distinctive thing about it is not so much how far its knowledge shall reach, as is the character of what that knowledge shall be. The goal of its striving is not to understand the constitution of the *matter* of which the world is composed, but of the *world itself*. Physical geography, geology, mineralogy, oceanography and astronomy are consequently no less provinces of natural history than are paleontology, botany, zoology and anthropology.

For the ends of general education, the study of natural history should beget the habit of mind of demanding the widest and exactest knowledge attainable touching any situation in life where decision and action are necessary; and it should provide the individual with a large fund of information, all so vitally correlated and intertwined as to give every faculty of the mind the greatest measure of sensitiveness and avidity for new knowledge and higher enjoyment. It should create a great complex of knowledge, the whole logical and rational substance of which should be penetrated through and through by a subdued emotional appreciation of the beauty there is in the great whole.

Such a knowledge would, perforce, hold the world in reverence even after all due regard were given to those portions of it which are unseemly and ugly and evil.

For the ends of scientific education and research, the study of such natural history would serve to counteract the tendencies toward sophistication which appear to be an inevitable concomitant of the rigorous mathematical treatment of such portions of nature as are amenable to these methods. Whatever the department of science to which any life may be dedicated, sufficient attention should be given to what is fundamentally involved in the elemental processes of observing, naming and classifying, to insure against the perils of ever forgetting that these processes are really fundamental to all natural knowledge.

To attempt to banish these simple operations from the august presence of exact science because one may to a considerable extent carry them on more or less automatically and unconsciously is folly, sure and disastrous, no less than would be the attempt to banish one's feet from the act of walking or his hands from piano-playing, because these members may do their parts, after once being well schooled, with little or no attention to them.

# THE AUTOMOBILE AND THE PUBLIC HEALTH

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SANITARY science has done so much towards the improvement of public welfare that it may not be surprising to credit the automobile with having contributed to produce some results. The question may be asked in what directions the public health is affected by the constantly increasing use of automobiles and autotrucks. A few considerations will make it apparent that horseless vehicles may bring about far-reaching betterment in human conditions. The enormous increase in the use of automobiles and autotrucks is bound to change some aspects of city life. There are possibly three directions in which the public health may be benefited, namely: (1) the improvement of streets and roads, resulting in reducing the amount of dust in the air, (2) the disappearance of the horse and horse stables from the neighborhood of human habitations and the consequent reduction of flies and (3) the avoidance of direct infections of stablemen and veterinarians, who come in contact with horses.

There are several reasons for the statement that improved street and road pavements will benefit the public health. Rough pavements offer opportunities for the accumulation of filth and dust. The stones, usually thought necessary for horses to get a good foothold, leave holes and crevices, where dust settles and the washings of streets from rain, snow or the sprinkling cart remain until dried out. The dry material is then dispersed by winds or passing vehicles and serves as means for carrying germs. Modern improved roads, with hard surfaces and sprinkled with oil instead of water, will prevent the rising of dust in large measure; sweeping of streets will become superfluous and the atmosphere will be purer and harbor relatively few microorganisms.

One of the most serious disturbances to efficiency of sewerage systems is the accumulation of dust, detritus and street sweepings, especially after rain storms. It is obvious that this trouble may be largely reduced through the improvement in pavements, which is advocated most enthusiastically by those interested in automobiles. Societies for road improvement are in existence to-day and the number is rapidly increasing. In some states of the union a goodly number of magnificent state roads has been built and although the movement is still in its infancy, there can be little doubt of the final outcome in regard to comfort and health resulting from the construction of good roads.

One of the missions of autotrucks will be the transferring of loading and unloading of freight beyond the city limits. The carrying of freight to warehouses on autotrucks will necessitate complete renovation of roads and construction of relatively dustless road beds. Incidentally this will also do away with much irritating smoke from locomotives. It has been stated that transportation of freight by autotrucks within city limits is economical both in time and expenditure. Improvement in city streets has followed in the wake of the introduction of electric street cars and the decreased use of horses in cities due to automobile traffic will increase possibilities in this direction.

The injurious influence of dust on the public health is of various nature. The mechanical irritation of the respiratory tract and the accumulation of dust in the lungs and eyes increase susceptibility to infections. Inflammations of the conjunctiva, due to infection with such common, usually considered innocent, germs as the ubiquitous hay bacillus, have occurred. Probably such infections follow mechanical irritation of the mucous membranes by dust or other causes. The hay bacillus is carried everywhere by dust. It must be remembered that dust is the carrier of germs—harmless as well as injurious ones. Bacteria, yeasts and molds rarely travel alone. They are generally kept in suspension by floating particles of dust. It is due to this fact that after snow and rain storms there are relatively few microorganisms in the air. Therefore any provision, which materially reduces the amount of dust will reduce the number of microorganisms in the air. Among such provisions improvement of road pavements takes a prominent place, since dust in the air can come only from the ground by the action of winds or moving vehicles.

The diseases which may be communicated by dust are manifold. The germs of pneumonia, various forms of tonsillitis, diphtheria, croup, whooping cough, colds and tuberculosis are undoubtedly carried by dust. In fact, probably all infections of the respiratory tract may be carried in this fashion. Germs of the diseases named have been isolated from the air. The germs of tuberculosis are carried chiefly by the sputum of affected persons and communicated either by inhalation of dust or by food on which germ-laden dust is deposited. It must not be understood that this is necessarily street dust, but no doubt street dust is a contributory factor.

Diseases of the intestinal tract may also be communicated by dust. Food and water, if contaminated with sewage, are the commonest vehicles of infection in typhoid fever and dysentery, but it is quite conceivable that some cases of obscure origin may be the result of dust inhalation or ingestion of raw food on which dust has fallen. Studies of typhoid fever epidemics have led sanitarians to recognize that food and water do not account for all cases and sometimes disease may be due to contact infection or inhalation of infected dust from the air. The infection of the saliva may then enter the system through the tonsils or the alimentary tract.

The skin of man and animals is constantly infected with many germs, some of which are responsible for boils and abscesses, erysipelas and certain diseases caused by molds or mold spores and yeasts. Dust is a factor of importance in carrying these disease germs to a place where they can invade the epidermis and bring about results which may become serious. The germs settle on the skin and await the first opportunity for multiplying at the expense of the tissues. Cleanliness is a far-reaching preventative and reduction of dust in the air promotes cleanliness.

One of the greatest benefits which will result from the increased use of horseless vehicles will be the disappearance of horses and horse stables from cities. This may not appeal to lovers of horses, but sanitary and preventive measures can not be carried out without sacrificing certain emotions. The germs and spores of lockjaw are common inhabitants of the intestinal tract of horses. Dust from dried horse manure may become the immediate cause of this dreaded and fatal disease. The spores of lockjaw germs are highly resistant and may live in the air and carry infection for months. A small amount of atmospheric dust entering a casual wound may result in serious diseaster, since a considerable portion of atmospheric dust is really dried horse manure. Another much feared disease is glanders or farcy. Horses are especially susceptible to this disease which causes a discharge from the nose, frequently looked upon in the initial stages as a cold. Carelessness may result in contact with this discharge which carries the virus and by means of abrasions of the skin of the stableman, rider or veterinarian the infection may be communicated. Glanders usually terminates fatally. Cases of this nature are by no means scarce. Both lockjaw and glanders will become less frequent with the disappearance of horses from our streets.

In some states and municipalities war has been declared upon the fly. There are at least two species of flies which interest us in this consideration, namely the house fly and the stable fly. It has been recognized that flies may carry disease germs and thus become important factors in spreading infection, not to take into account the discomfort, caused by flies, to man and animals. In *The American Journal of Public Health* of December, 1913, is reprinted part of an article of the September number of the Department of Public Safety of Rochester, N. Y., giving some interesting figures on manure production and its relation to the fly problem.

There are 15,000 horses in the city. The average output of each horse consists of thirty pounds of manure and eight pints of urine per day. It means that the 15,000 horses deposit on the streets and in the stables of Rochester over 82,000 tons of manure annually. The total manure output of the city would make a pile covering an acre of ground 175 feet high. If every pound of manure exposed furnished a breeding place for 100 flies, then we should have, as a result of this large pile of manure 16,400,000,000 flies. We can no longer rely upon the slogan "Swat the fly," and we must get rid of the fly by starving it. We must clean up, so that there is nothing upon which the fly may feed; no decaying material in which to lay its eggs. "Starve the fly," must be the slogan. It is almost enough to make one give up hope and conclude that the automobile is the only solution.

The campaign against flies is based on study of the life history of the fly. These studies have demonstrated that manure is one of the commonest places for fly breeding. A comprehensive book on this subject has been published by Edward H. Ross, entitled: "The Reduction of Domestic Flies." Some of the following statements are taken from this book.

The house fly breeds in all sorts of filth, but stable manure is the commonest lair for the insect. The female fly likes to lay her eggs here and in horse dung the fly maggot or grub lives for five days and then becomes the chrysalis or nymph. After about five days more the fully developed insect emerges to become a nuisance and do its deadly work. Fly reduction is a beneficial measure because it brings about a saving of life; reduces sickness, sorrow and misery; results in riddance of a pest and facilitates sanitary inspection. It has been estimated that one fly can produce in one month 506,250,000 offspring. Supposing only one half of these survive the larval stages, we have the enormous total of 250,000,000 increase per month.

The author of this book also states that "In the West End of London the stables and mews have become garages and there are only a few flies, where formerly thousands pestered, . . ." The disappearance is due, in part at least, to the removal of the horse manure and with it the favorite breeding places for flies. The campaign against flies, therefore, consists largely in prompt disposition of horse manure. That the most efficient method of disposition is the removal of the horse is obvious and with the advent of horseless vehicles the horse becomes superfluous. Considerable success has already crowned efforts in caring for the excrements of horses and the banishing of horses from our streets will facilitate this work. With the consequent reduction of flies we shall rid ourselves of a disgusting pest and aid in the preservation of life, health and happiness.

Evidence of the rôle played by flies in carrying infection is not wanting. In the Spanish-American war much of the typhoid fever was ascribed to the presence of flies. They were so common that, when cooked food had cooled sufficiently, it was covered with flies. When eating the men had to keep the flies away with one hand. Fecal matter in the pits was covered with lime and the white specks from the feet of flies could be traced on food. Virulent tubercle bacilli, the germs of typhoid fever, of bubonic plague, of anthrax and of Asiatic cholera have been found on the feet or in the intestinal canal of flies. Infection of milk by flies is a common occurrence. Hundreds of bacteria have been counted on the feet of flies caught in the cow stables.

Some sanitarians believe that many infant lives would be saved if the fly could be kept away from the baby's milk. A recent investigation in New York City carried out by Dr. Donald B. Armstrong (published in the *Journal of the American Medical Association,* January 17, 1914,) seems to show that there is some connection between flies and infant mortality. The author's results seem to indicate that the fly is a much neglected factor in the etiology and transmission of summer diarrhea. He thinks that greater attention should be given to the elimination of the insect by all those interested in prevention of infant mortality. Two areas were covered by his investigations, both practically alike in population and other conditions. The first area was subjected to every possible precaution against flies. The means were educational campaign, exhibition of picture films of flies in a nearby theater, screening of the 1,700 doors and windows, and placing of large fly traps in the courtways, yards and stables. The second area was permitted to pursue its usual insanitary course. In the protected area the total days of sickness of diarrheal diseases among infants was 273, in the unprotected area 984.

According to Farmer's Bulletin 540, U. S. Department of Agriculture, the stable fly, also known as the wild fly, the straw fly and the biting house fly, commonly breeds in horse manure, especially if straw is present, as is usually the case. It has been believed, although lacking confirmation, that infantile paralysis and pellagra are communicated by this species. It has been more definitely demonstrated that this fly is instrumental in spreading some diseases of domestic animals. Aside from these facts it is a tormentor of live stock. Horses and cattle suffer more than other animals, but sheep, goats, hogs, dogs and cats are known to be infected by these flies. Even man is not immune. A tropical disease of camels, horses and cattle, known as "surra," is communicated by this fly. Anthrax, glanders and possibly other diseases of cattle, also communicable to man, may be transmitted by the stable fly. Although the chief breeding places are straw stacks, the manure piles commonly found near stables where horses are kept furnish suitable breeding places. Adult flies may follow for considerable distances traversing roads and, when engorged with blood, settle on nearby objects. Other teams passing along the same highways are subsequently attacked. It is evident that with the reduction of horses and horse stables this pest will be greatly reduced.

Flies do not generally act as intermediate hosts in the transmission of disease. Usually they carry the germs on their feet or in the intestinal tract and infect food by walking over it or dropping on it. The danger from flies is greater than from mosquitoes. The latter act as intermediate hosts and carry the virus of malaria, yellow fever and other diseases.

The germs of these diseases undergo a well defined cycle of development in the body of the mosquito. For mosquitoes to become a menace it is necessary for them to bite a human subject suffering from malaria or yellow fever after which a period of incubation has to elapse before the bite of the insect becomes dangerous. This incubation period lasts somewhere from ten to twelve days. Direct infection by mosquitoes as mechanical carriers of germs is relatively scarce. Besides, mosquitoes are not universally susceptible to the diseases mentioned. Only certain species can act as intermediate hosts. Since flies are mechanical carriers the possibilities of infection by these insects is greater than by mosquitoes.

The probable benefits that will result from the increased use of automobiles and autotrucks may be summed up as follows: (1) With the universal construction of smooth and non-absorbent roads and the use of oil instead of water for sprinkling, the quantity of dust in the air will be reduced. As a consequence a number of diseases which are frequently transmitted by dust will be decreased and storm waters will be more easily cared for. (2) The horse will gradually disappear from our streets. With it the number of house flies and stable flies will be diminished; human lives will be saved and much added to health and comfort. Contact infections of those engaged in the care of horses will also become rare. At the same time out of door life and enjoyment will be encouraged and thus a further contribution to the betterment of human conditions brought about.

# TROPICAL NATURE IN COLOMBIA

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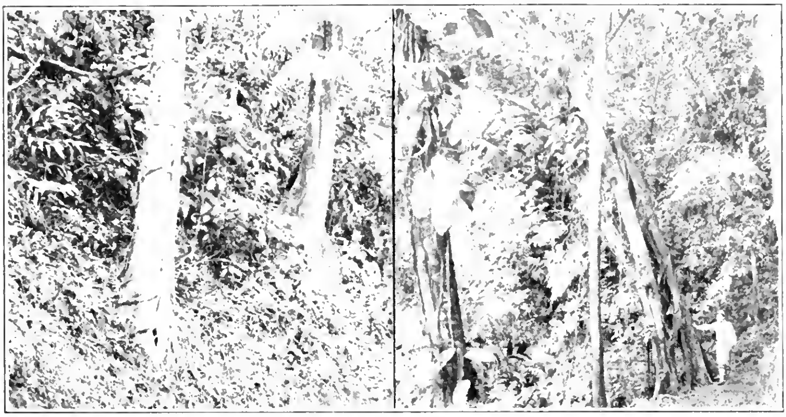
FOR the naturalist reared in temperate climates the tropics will always be a promised land flowing with biological milk and honey. The medical men have been pioneers in opening up this *terra incognita,* though they were not the first to enter it. Tropical diseases are no longer looked upon with the dread characteristic of our grandfathers, but for the most part may be as well controlled as those of cooler climates. Though there is still a small element of uncertainty to add savor to tropical exploration, the naturalist of to-day may travel to the edge of an unknown country in a modern steamship and go forth to discover new things with a complete outfit of the latest scientific equipment—if he has the money to buy it. The tropics are the same as when Bates braved the terrors of the Amazon, but modern commerce and modern medicine have made it possible to travel with more or less comfort, and such simple aids as fly dope, quinine, and mosquito netting permit one to penetrate regions which were impossible fifty years ago.

The present article attempts to describe tropical nature as it exists in northeastern Colombia along the northern end of South America, just south of the Caribbean Sea. The descriptions are based on observations made while the writer was a member of an expedition sent by the museum of zoology, University of Michigan, to explore the region about the old Spanish city of Santa Marta. This portion of South America offers unusual opportunities for zoological study on account of its diversity. A strip of sandy desert overgrown with giant cactus stretches along the coast and extends back into the interior seven or eight miles. Beyond this the foothills of the Sierra Nevadas rise; only twenty miles from the city the peaks attain a height of 8,300 feet above sea level. Many small streams take origin in the mountains and unite to make their way across the lowlands to the coast. Extensive mangrove swamps line the shores of the Cienaga Grande, a great lagoon into which several rivers empty.

The members of the expedition were met as they stepped on Colombian soil by Mr. William A. Trout, the American consul at Santa Marta, Mr. M. A. Carriker, and Mr. O. Flye. These gentlemen and their families did everything they could to make our stay pleasant and profitable. The Colombian government was also extremely courteous, allowing our outfit to pass the customs without inspection.



STRANGLER TREES. The figure at the left shows a young strangler, that at the right shows an old one. The tree about which the latter wrapped itself was killed and has rotted away.

Starting the day after our arrival we rode eighteen miles into the interior on mule back to the Cincinnati coffee plantation, the home of Mr. Flye. That ride was wonderful! As we went higher the luxuriance of the vegetation increased and the trail often hugged the brink of a precipice where one could look for miles over the virgin forest and banana plantations below. Like the hunter in the "Lady of the Lake," we

> often paused, so strange the road,
> So wondrous were the scenes it showed.

We lived at the plantation for a month in a clean little adobe house at an altitude of 4,500 feet. In half a day we could walk down to Minca, at about 2,000 feet, or up to the top of San Lorenzo, 8,300 feet. Beyond the coffee the tropical forest stretched away unbroken: in one direction to the desert along the coast, in the other toward the snow peaks at the crest of the Sierras. Every afternoon it was cloudy, usually there was rain.

BUTTRESSES.

### The Tropical Rain Forest

Two things are noteworthy in comparing tropical forests with those of colder regions: the diversity of the vegetation, and the intensity of the struggle for existence. In the temperate or frigid regions of the earth which are forested we are accustomed to see one species or genus of trees dominate all other plants and become a "climax forest," *e. g.*, oak, pine, spruce, beech forests. But in the tropics conditions are favorable for many species; the growing season is always good, and the forest is always varied. Tree ferns, palms, vines, deciduous trees, epiphytes, mosses, ferns—all grow in riotous confusion. Vines climb over great

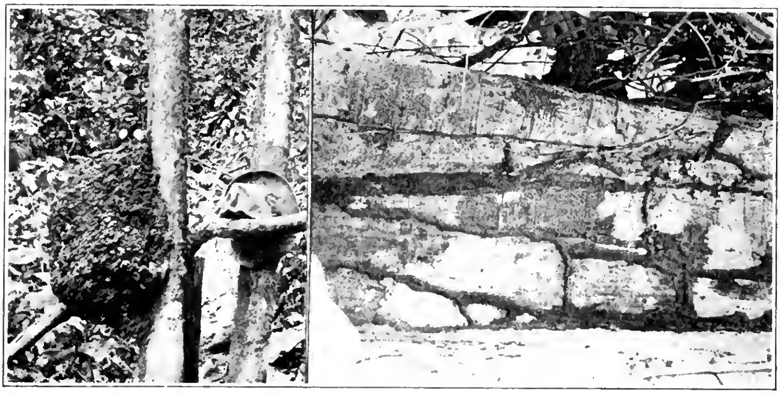
A Tree Fern.

trees and steal their sunlight; strangler trees grapple with forest giants, squeeze them out of existence, and take their places; epiphytes and mosses festoon the limbs of trees, stretching their leaves toward the light that filters through the canopy above. Any handicap means that a tree must give way to more successful rivals, and many drop out. But the floor of the forest is not always strewn with the remains of the unsuccessful, for where it is not too wet the termites, or white ants, honeycomb every bit of dead timber and convert it into powder, which in turn is soon "resolved to earth again." Thus the cycle goes round and tree succeeds tree. One who lives in a temperate climate has no idea of the manifold intensity of the struggle among the plants in tropical forests.

In the midst of such a struggle one would expect to find a great variety of adaptations for surviving, and such is indeed the case. Many trees have wide props or buttresses extending out from their bases which stiffen them against the fury of tropical storms. Some trees have thick bark which is scaled, or smooth, or ridged, or ringed, or spiny, or what-not; some scarcely have bark at all, but are smooth and naked. Palms not only grow in the conventional form, but many masquerade as climbing vines or epiphytes. Everywhere there is specialization and adaptation along many lines.

The humid shade of the forest offers shelter to many animals which, like the plants, show a great variety of adaptations. A large number of animals depend directly on the plants for food. The lowly termites are quick to appropriate any dead or diseased parts; vegetarian ants swarm everywhere. Long-tailed Kinkajous come forth at night to climb about in the mango trees; wood rats, squirrels and agoutis feed upon the luscious aguacates ("alligator pears"). Many birds have become specialized for fruit eating: flocks of gaudy parrots squawk among the trees, resplendent toucans wipe their great beaks against the limbs which have borne their repasts. In addition to these specialists many other birds eat fruit when it is available: trogons flit shyly here and there, and conceited motmots perch so that they may proudly wag their beautiful tails from side to side. Yet the denizens of the tropical forest do not appear gaudy and highly colored. A parrot is indeed a splendid object when you hold him in your hand, but stand below a mango tree and you are amazed to find that it is practically impossible to see any of the flock which are squawking noisily through its foliage. Only by watching carefully for movement can you pick out a bird here and there.

Besides the animals which hunt in the trees many wander about over the ground beneath. These are usually not brightly colored. Tapirs were common about the plantation, and one was killed by the workmen during our stay. These pachyderms had regular trails like cow paths through the forest. Droves of peccaries rooted in the ground and we often saw places where they had been feeding, but that was all. Mr. Flye told us how he had once been treed by a drove of these ferocious "wild hogs" which stood about and gnashed their teeth for a couple of hours. Jaguars and tiger cats hunted in the forest. One day a small boy brought us an armadillo. Agoutis were common everywhere. Once, while I rested at the fork of a river a great agouti came to drink fifty feet below. My Colt was at my hip, but I did not have the heart to shoot him—so much at ease was he, so self-contained, and so in keeping with his forest. He took his drink and went away, never knowing that a strange gringo had watched. Another time we saw a troup of big red monkeys swinging along through the tops of the trees, but they quickly scampered away when they spied us. We always went armed with gun or pistol hoping that we might bag one of the larger mammals, but fate was against us. The large animals are extremely shy and their colora-



A Termite's Nest in a Tree. Note the covered roadway passing down the tree trunk which bears the nest. The figure at the right shows the covered roadways of termites on a tree trunk.

tion makes them difficult to see. To secure them one must attend to little else. Our interests were not in big game, but we were well repaid with smaller fry—the forest filled our eyes, and notebooks, and photographic films to overflowing—yet never to satiety. There was always something new and interesting.

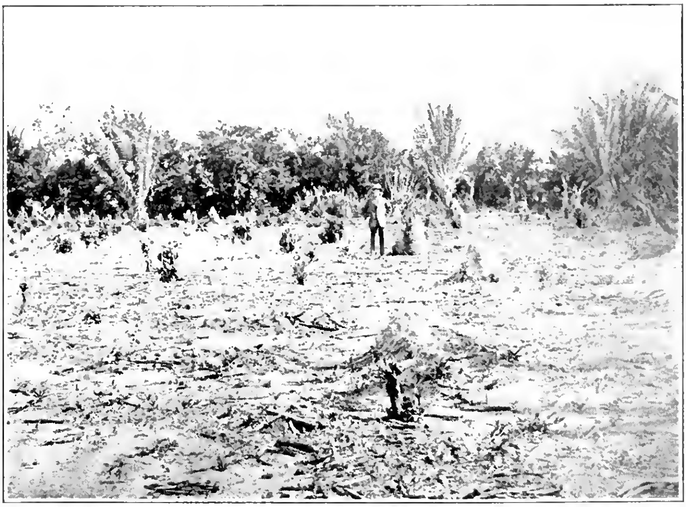
The forest swarmed with lizards, such as the little anoles and geckos, which crouched motionless or scampered swiftly after fleeing insects. Snakes lurked among the fallen leaves or climbed among the trees—gaudy coral snakes with their cross bands of red and yellow, the vicious fer-de-lance or bushmaster (called "*Ecke*" by the Colombians), big, but harmless, gopher snakes. Sometimes we met a "Bejuca" (vine snake)—the most curious of them all—never half an inch in diameter and attaining a length of three or four feet. But snakes were not easy to find. We rarely got more than two or three in a day, sometimes one, often none. Scorpions, tarantulas and other spiders abounded throughout the forest. Big land snails crawled on the trees or over the ground. Bright-colored butterflies fluttered in flocks through the open spaces. Probably the most typical forest vertebrates were the little tree frogs, which were abundant and various, and whose shrill piping was often the only sound to break the deep silence.

At night we took our jack-light (an acetylene lamp mounted on the front of a hat or carried in the hand) and sought nocturnal animals. On these excursions *Bufo marinus*, "the giant among toads," was always encountered. Another curious toad, a *Ceratophrys*, was dubbed the "snapdragon" by Dr. Ruthven on account of its fierce behavior. It would snap at us and grasp the end of a stick in its mouth, hanging on firmly while it was swung about in the air. Goatsuckers and bats often came right up to the light and flew about over our heads. Snakes were active too, and we often flashed the light on one of them, hunting in the night.

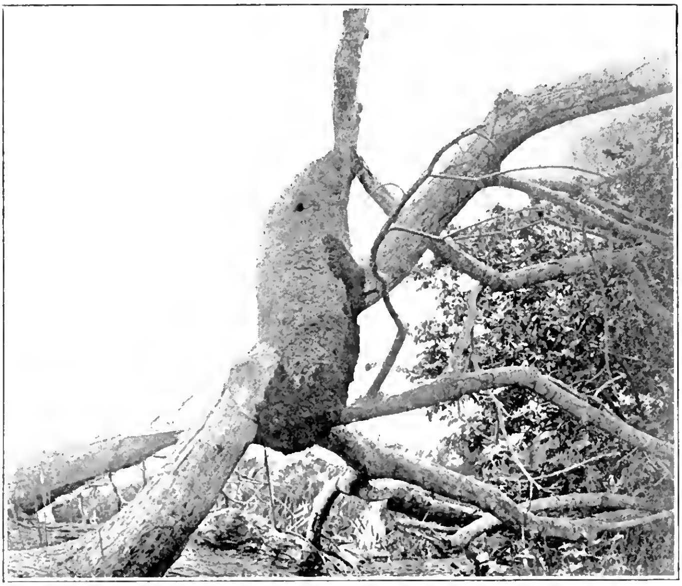
Under fallen logs we found an admirable hunting ground for various invertebrates. Land crabs were often unearthed at considerable distances from the water. Centipeds of all sizes were abundant, some of them twelve to thirteen inches in length. Many millipeds and centipeds were found in their little nests where they lay eggs and rear young. Some of these nests were simple hollows in the soft pulp of rotting logs, others were carefully made dome-like structures formed from little pellets of mud. But the greatest find under fallen logs was the curious *Peripatus*, a primitive arthropod which resembles the segmented worms in many characteristics. These beautiful velvety animals glide slowly along, feeling their way with the two antennæ at the anterior end. If touched, they turn about and squirt two viscid threads from beneath the head. These threads, which harden quickly, serve to capture prey or entangle aggressors.

Termites were abundant in dry places everywhere up to an altitude of about 5,000 feet. They never come out into the light, but always construct covered galleries of wood-dust, dirt, excrement, etc., wherever they go. Some species live in the ground and build great mounds over old stumps and logs; others make mud nests on tree trunks from which they build galleries in various directions. These insects live in great colonies in which there are usually several enormous egg-laying queens and thousands of workers and soldiers. They eat away a piece of wood so that the interior is converted into a powder while the exterior is perfect. A log is thus reduced to a thin shell which crumbles at a touch.

Probably the most characteristic and interesting animals in tropical

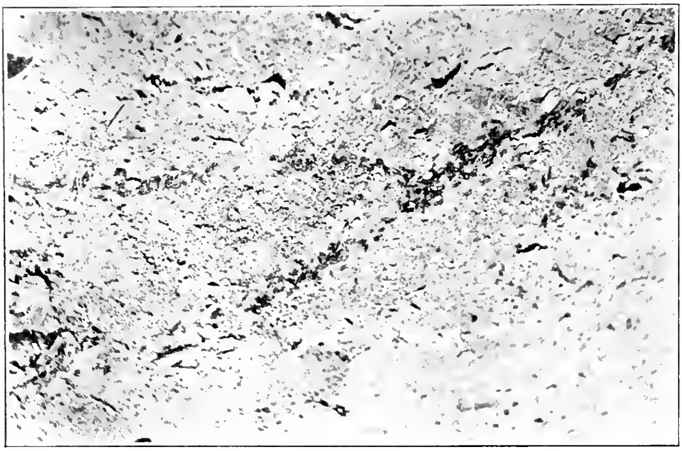


TERMITE NESTS IN A FIELD.



A Termite's Nest on a Dead Tree. Note that a woodpecker has made a hole near the top.

forests are the ants. Attention is at once attracted to the leaf-cutters which toil ceaselessly through the night and during most of the day, only intermitting their labors during the hottest part of the afternoon. These ants make big mounds, sometimes twenty feet in diameter, with numerous entrances. The underground galleries are continually extended and modified for there is an excavating party at each mound which carries little particles to a particular spot at some distance from the



Foraging Ants Crossing the Trail.

entrance where there is a dump pile. Other individuals of the colony are constantly moving along pathways in the forest carrying pieces of leaves. The same paths are evidently used for a long time as they may be six inches wide and worn (by the ants and rains) to an inch or two below the surface of the ground. An ant cuts a bit of a leaf, using his mandibles like a pair of scissors, and carries it into the nest. Here the leaf fragments are chewed into a pulp, spread out in beds, and planted with fungus. The sole food of leaf-cutters consists of fungus raised on vegetable pulp.

The driver ants go through the forest in great swarms cleaning up all the small live things as they travel. They have no home or perman-

In the left-hand figure the white mass is a fungus garden of a leaf-cutting ant. The thorns shown at the right are occupied by small ants. Note the small opening which leads into the cavity within each pair of thorns.

ent abiding place, but carry their eggs, pupæ and food with them. There is never any doubt when drivers are at hand, for all the sow-bugs, crickets, and other small creatures which usually hide in crevices are out in the open hopping hither and thither in frantic efforts to escape. The drivers we saw were small blind black ants which formed a veritable carpet over everything as they progressed. They covered the ground, searching every nook and cranny; they climbed each tree, slowly, methodically, carefully; they left no place unexplored; next day they were gone.

The foraging ants are somewhat like the drivers. They are larger and many individuals have great white heads provided with a pair of


In a Banana Plantation. Each tree is cut down when its single bunch of fruit is harvested, but new sprouts grow up from the root. 500,000 bunches of bananas are shipped from Santa Marta each month for New York.

enormous recurved mandibles. Like the drivers, these ants carry all their impedimenta with them. Those we observed always traveled in narrow columns which flowed ahead like living streamlets, branching out and reuniting over and over again. Foragers always appear to be in great haste and go scuttling along carrying pupæ, larvæ, pieces of dismembered insects, spoil from the nests of other species of ants, etc. We saw some foragers form long covered lanes with their bodies by clinging to each other with their mandibles and legs. Through these covered roads other individuals of the swarm scooted along—these were robbers carrying booty from the nests of other ants.

A Bromeliad.

Many ants manufactured a sort of dirty paper from which they built hanging nests in trees. Others excavated logs like termites. One of these Mr. Gaige, our ant man, called the "spread-eagle nipper." This was a big black ant which opened its mandibles so wide that they stood out straight at the sides of the head, and then brought them together with a snap that could be distinctly heard at a distance of several feet. Woe to the unwary finger that was between those mandibles when they came together!

At Fundacion, a village in the forest beyond the banana country, we discovered two curious species of ants living in trees. One of these built little paper sheds over aphids which it put out to "graze" in the acacia trees. The aphids sucked the juice from the trees and gave out a sweet secretion which was taken from their bodies by the ants. The other species mentioned lived in little hollow thorns on the branches of an acacia. This tree was a true ant plant for it grew the hollow thorns in pairs with a little doorway leading into the cavity within them. The doorways were present in young thorns even before the ants had occupied them.

We can not pass the forest without mentioning the bromeliads. These plants are members of the pineapple family and are much like pineapple plant without the "apple" at the bottom. High up in the mountains they grow on the ground, but as the altitude grows less they begin to climb upward, and in the lowlands live as epiphytes in the trees. The bases of the leaves interlock in such a way that they make tight cups which act as reservoirs for the water that runs down from the tips of the leaves. The water contained in one of these plants frequently totals to two or three quarts, and the thirsty traveler is often glad to make use of it. Many small animals pass their lives in the shelter of bromeliads. We found tree frogs with their eggs, dragon fly larvæ, rat-tail (fly) larvæ, beetles, cockroaches, spiders, salamanders, and many other small animals. We tore open logs for two weeks and found only two salamanders, but got twenty from the bromeliads in a single morning.

### The Desert

The strip of sandy country near the shore of the Caribbean Sea grows cactus and various xerophytic shrubs. Many of the cacti are thirty feet tall. Here the most characteristic animals are the ground lizards which swarm over the sand everywhere. Many of these are brightly colored with yellow or blue.

We were surprised to find land snails quite abundant in the desert. At the time of our visit they were æstivating in the crevices of curiously twisted trunks of the small acacia trees. Here also we occasionally found a land tortoise (*Testudo tabulata*) wandering about among the cactus. Several streams ran through the desert. Near these the little

Desert Snails Aestivating in the Twisted Trunk of a Desert Tree. Mangrove Seeds.

conical pits of ant lions often covered the ground so thickly that it was impossible to avoid walking on them.

Once near the sea we came across a great number of terrestrial hermit crabs, *Cenobita diogenes*, each encased in the shell of a land snail. The little army was moving slowly through a rocky portion of the desert where its members could sidle quickly from the shelter of one rock to that of another. These little crabs live a truly terrestrial life, and return to the ocean only once a year, when they breed. They apparently require very little water, for I brought three home with me and they have lived in a dish of dry sand in my office for more than six months. They have of course been supplied with food and a small cup of drinking water.

This desert, like those in other parts of the world, has a rather sparse fauna consisting of a few species, most of which are able to stand extreme desiccation, long fasts and great heat. The lizards and tortoises with their dry, scaly skins, the land hermits with thick exoskeletons and borrowed shells, the land snails with thick calcareous coverings, are all admirably suited to desert conditions.

## Brooks and Rivers

The streams on the northern Colombian coastal slope are easily divisible into two classes—mountain torrents and rather slow-flowing meandering rivers. From headwaters in the mountains the water rushes down over rocky beds for a time, then comes abruptly to the level sandy plain where much of its impetus is soon lost.

The most striking characteristic of the animals of the mountain torrents is their ability to hold on. The little catfish found there have a free spine on the pectoral fins which enables them to cling tightly to the rocks; the caddis fly larvæ are all fastened firmly by threads; the water bugs are greatly flattened so that when they cling to a rock their bodies offer little resistance to the water. On the surface of the brooks enormous hairy spiders with ridiculously small bodies hunt for a living.

The tree frogs in the mountains were hard pushed to find a place to breed, for there was no standing water on the ground. They either carried their eggs on their backs or laid them in the bases of bromeliads. Many of the aquatic animals which are characteristic in other parts of the world are lacking in the mountain streams. There were no snails, pill bugs, or amphipods. The fauna was a specialized one—limited mostly by its ability to avoid being swept away.

In the slow rivers of the lowlands the most characteristic animals were the shrimps and prawns which often possessed greatly elongated claws. Curious little shrimps belonging to the family Atyidæ were quite common. These crustaceans have the first two pairs of legs modified into little brush-like forceps with which they scrape the microorganisms from the soft bottom or from aquatic plants. Many land and freshwater crabs lived along the shores of the rivers. Among these *Cardiosoma guahumi* was most conspicuous on account of its blue color and large size. This big crab digs holes in the mud beneath the trees near the mouths of rivers. It comes out at night seeking food and climbs the trees to eat the leaves. It was a great sight to watch hundreds of these crustaceans on the mud flats, sitting motionless in the glare of the jack-light.

Along all the streams below 2,500 feet there were many lizards of the genus *Basiliscus*. These animals have a very long slender tail and small front legs. When disturbed they stand nearly upright and run swiftly over the surface of the water, using only the hind legs and the tail, like the ancient dinosaurs. In the trees along the rivers we encountered many iguanas. These big lizards sit in the trees and if disturbed often

A LAND CRAB, *Cardiosoma guahaumi.*

Mangroves Growing at the Edge of the Cienaga Grande.

dive from a height of thirty feet or forty feet into the water, swim underneath the surface to the opposite bank, crawl out and hide. We shot one iguana that measured 4 feet 9¼ inches in length.

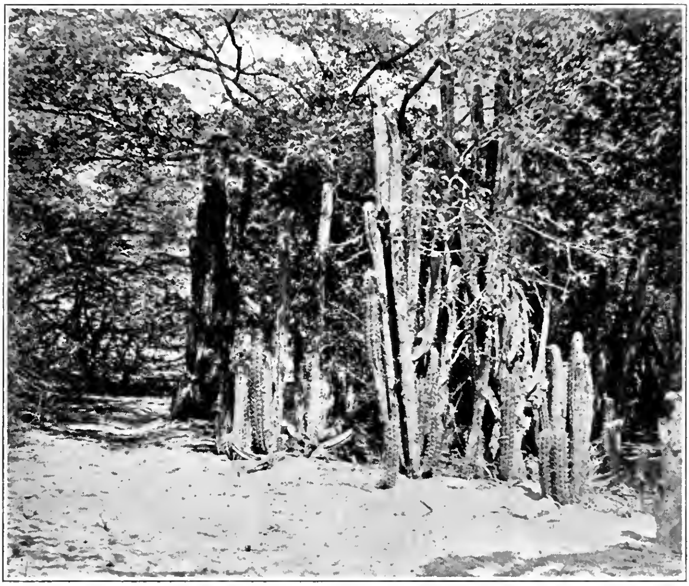
## Swamps

Many of the plants which are raised in hothouses or summer gardens in the United States are common weeds in Colombia. In the forest calladiums and cannas grown everywhere; umbrella plants line the shores of all the streams; in the swamps cannas and umbrella plants

The Ford at Minca, at an Altitude of about 2,000 Feet.

constitute an important part of the flora. In some swamps there was a slender stemmed plant which had little white air bladders to keep it at the surface.

The jacana, a rail-like bird, is admirably adapted to live in tropical swamps. The greatly elongated toes enable this bird to walk with ease over the floating vegetation. Both sexes have a spur on the front of each wing which they use in fighting. A flock of jacanas is a beautiful sight as it alights, for every bird stretches its yellow-tipped wings as far upward as possible before closing them. Another swamp bird was a



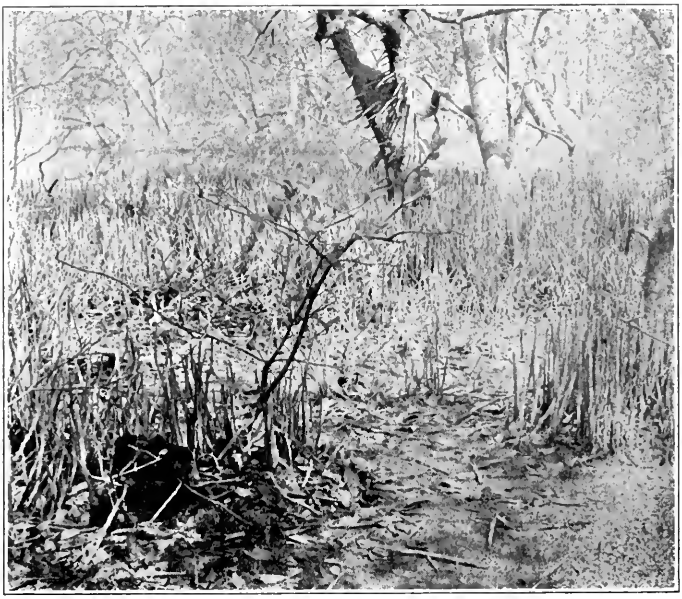
Giant Cactus and Desert Trees.

species of tree-creeper which built a long bottle-shaped nest, which was constructed of thorny twigs in low shrubs. The eggs were placed in a little enlargement at the closed end and the long thorny entrance prevented snakes and other predaceous animals from entering.

The swamp water swarmed with aquatic bugs, beetles, snails and other animals. One large snail always climbed out of the water to deposit its beautiful rose-pink cluster of eggs on the stems of plants. Around the margins of the swamps there were many land crabs, snakes and peculiar engistomatid toads. Tropical swamps constitute an admirable habitat for many animals. The abundant vegetation and small animals fill the water with an organic network which supports many larger predaceous animals such as fish, herons, ducks, jacanas and snipe.

### Mangrove Swamps

Mangroves are found only along the muddy shores of salt or brackish water in the tropics. These peculiar trees play an important part in land formation in such places for they keep growing farther and farther into the water and the accumulation about their roots makes new land. They are admirably adapted to live in mud flats. Roots branch out from the trunk in every direction and keep it upright on the soft bottom. The seeds germinate before they drop off, each forming a long spike-like root which penetrates the mud so that it is not washed away after it falls. Roots are sent along just beneath the surface of the mud and many small aerial rootlets grow upward from these which enable the



Mangrove Swamp. Prop roots support the small tree in the foreground and are growing down from the large tree further back. Many aerial roots are sticking up from the mud.

mangroves to survive in the salty water of the foul mud flats by absorbing substances from the atmosphere.

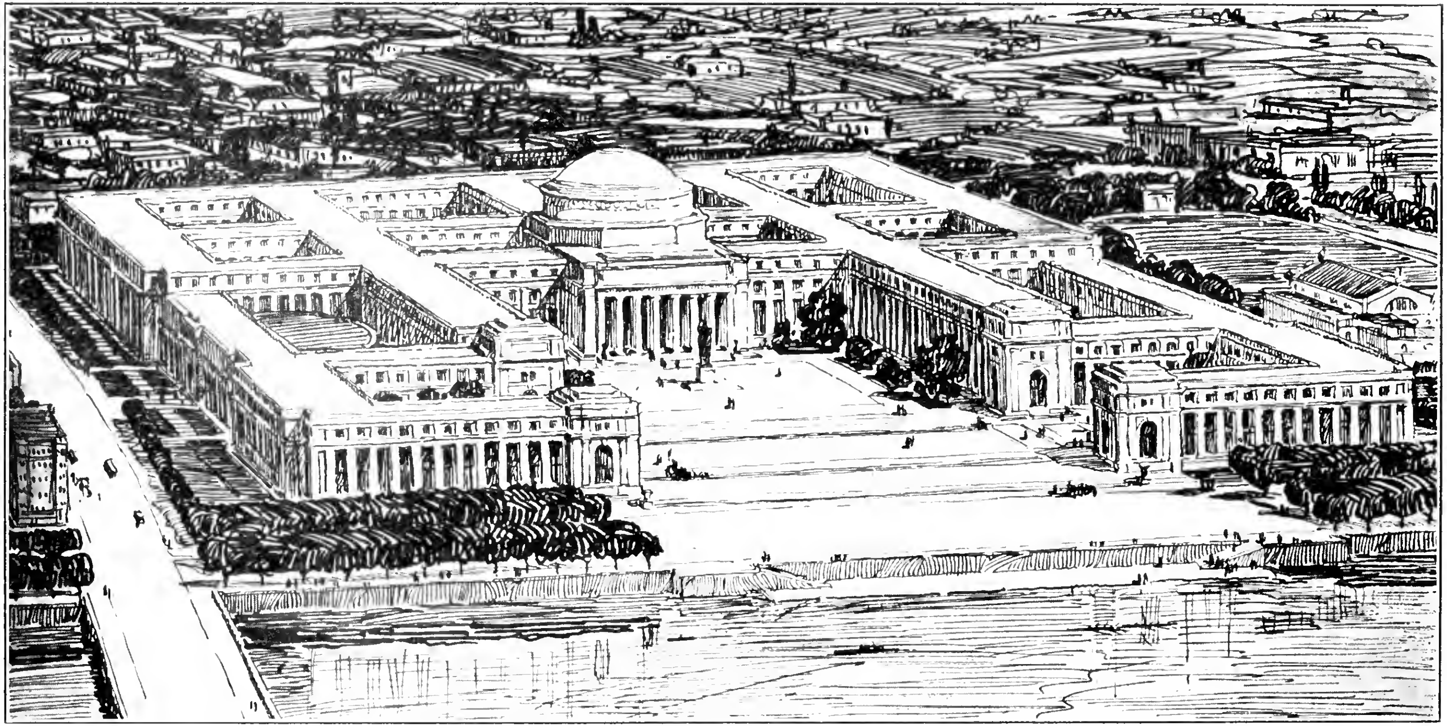
In the mangrove swamps along the Colombian coast we had a most exciting time. Mr. Trout towed our bongo (dug-out canoe) out on the Cienaga Grande, a large estuary, with his launch, and we spent several days at the edge of the mangroves. At night we were obliged to pull out into the middle of the Cienaga, for the mosquitoes were unbearable. One evening a vampire bat took the liberty of biting one of the party on the top of the head while he slept. Two of us had been hunting with jack-lights and on returning found him with his hair full of blood.

Often half a dozen of these little bats would settle over the roof of the boat after dark and compel us to move elsewhere to sleep.

Fiddler crabs swarmed among the aerial roots of the mangroves and Sesarma crabs climbed about over the prop roots and trunks. Crocodiles fished along the shore and the slapping of their tails was often the last sound we heard at night. Among the trees there were thousands of herons and many cormorants; sandpipers swarmed along the shores of the lagoons. Occasionally we met rarer birds, such as the beautiful roseate spoonbill.

Back of the mangroves along the shores of the Cienaga Grande we had our best jack-lighting. As the light moved along the eyes of the raccoons glowed like pairs of fiery cherries, now and then a deer crashed in the brush, and occasionally a big ant-bear lumbered away through the dark. Shooting at night is not easy. There is no target but the shining eye of an animal. Nevertheless, Mr. Trout shot a fine buck deer and a seven-foot crocodile. The former was hit in the center of the forehead, the latter, though shot from a canoe, was pierced cleanly through one eye.

In closing I must speak of my two companions, Dr. A. G. Ruthven and Mr. F. M. Gaige. It is no small test of friendship to be with two other men day and night for three months in a strange country. One has an excellent chance to become tired of his companions. But these gentlemen were so cheerfully unselfish in bending every energy to further the cause of science by making the expedition a success, so patient during the trials which always come in a tropical climate, that, though I had known and liked both for years, I came back home with increased admiration and respect for them.


Sketch of the New Educational Buildings of the Massachusetts Institute of Technology.

# THE PROGRESS OF SCIENCE

## *WORK IN ENGINEERING AT HARVARD UNIVERSITY AND THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY*

The corporations of Harvard University and of the Massachusetts Institute of Technology entered into an agreement in January, according to which all work in mechanical, electrical, civil, sanitary and mining engineering will be conducted in the new buildings of the Masachusetts Institute of Technology on the site recently acquired by the institute on the Charles River embankment in Cambridge, not so very distant from the site of Harvard University.

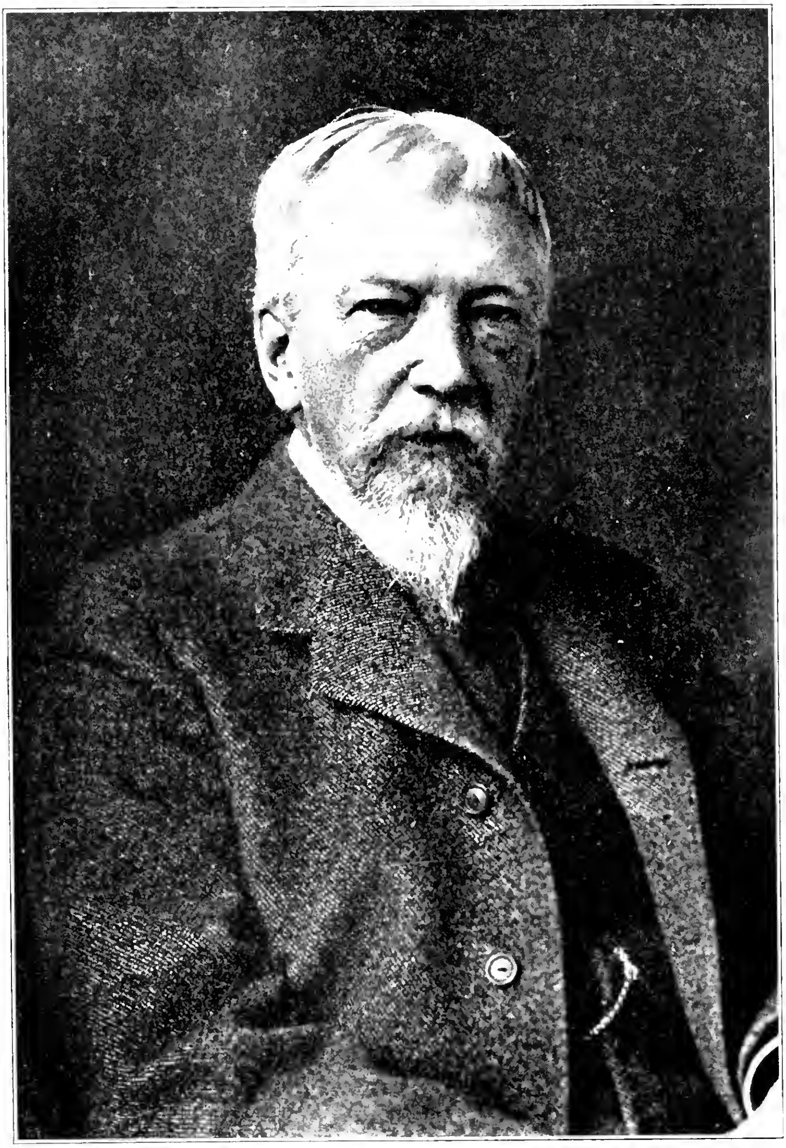
The university agrees to devote to the courses in engineering the income of the funds of the Lawrence Scientific School and the use of equipment not more urgently needed for other purposes, together with not less than three fifths of the Gordon-McKay endowment. This will provide at present some $60,000 a year, and may ultimately amount to more than $250,000. The institute devotes to the work all funds that it now holds for the purpose, and both institutions agree to use in future all funds acquired for the promotion of teaching and research in engineering. Buildings are to be erected only from the share of the funds supplied by the institute. All funds are to be expended through the bursar of the institute, but the corporation that supplies the funds is to prescribe the way in which they shall be expended.

All members of the instructing staff in the engineering departments referred to who give instruction in courses leading to degrees in both institutions are appointed and removed by the corporation that pays their salaries after consultation with the other corporation. The faculty of the institute is to be enlarged by the addition of the professors, associate professors and assistant professors in the school of applied science of Harvard University, and at the same time the professors of the institute receive the title and privileges of professors of the university. The president of the institute is the executive head for all work carried on under the agreement and is to make an annual report to both corporations. When a future president of the institute is to be selected, the president of Harvard University is to be invited to sit with the committee that recommends the appointment.

Students at the institute in the engineering courses mentioned are admitted to be candidates for degrees at Harvard University and have the same rights and privileges as students in the other professional schools. Students may receive degrees from either or from both institutions.

Both institutions are unaffected in name, organization and rights over their property and either institution may terminate the agreement on notice of at least five years, or a shorter period if mutually agreed on.

It will be remembered that some eight years ago the corporations of the Massachusetts Institute and Harvard University voted a plan of affiliation which was later abandoned owing, it was said, to the fact that the institute could not sell its present site for business purposes, though in fact the abandonment of the plan was due to opposition on the part of the faculty and



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DR. S. WEIR MITCHELL,

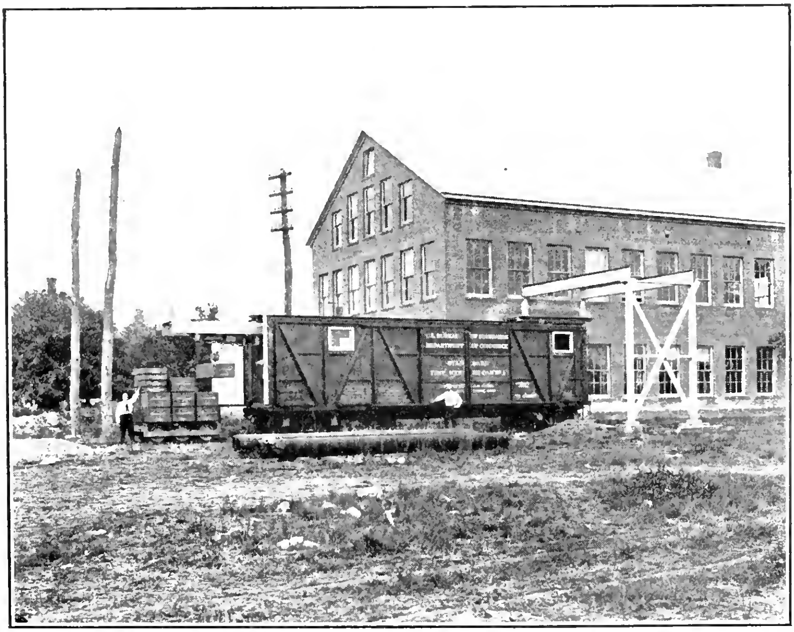
The distinguished man of science, author, physician and citizen of Philadelphia, who has died at the age of eighty-four years.

alumni of the institute. The former plan would have in large measure merged the institute in Harvard University; the present plan seems to use the funds of the university for the support of the institute. It may, however, be that both institutions will gain by the arrangement and both President Lowell and President Maclaurin emphasize the fact that educational institutions do not exist for their own glory, but for the welfare of the community as a whole, and that the combination of resources of the two institutions will provide a school of engineering at present unequalled in this country and perhaps in the world.

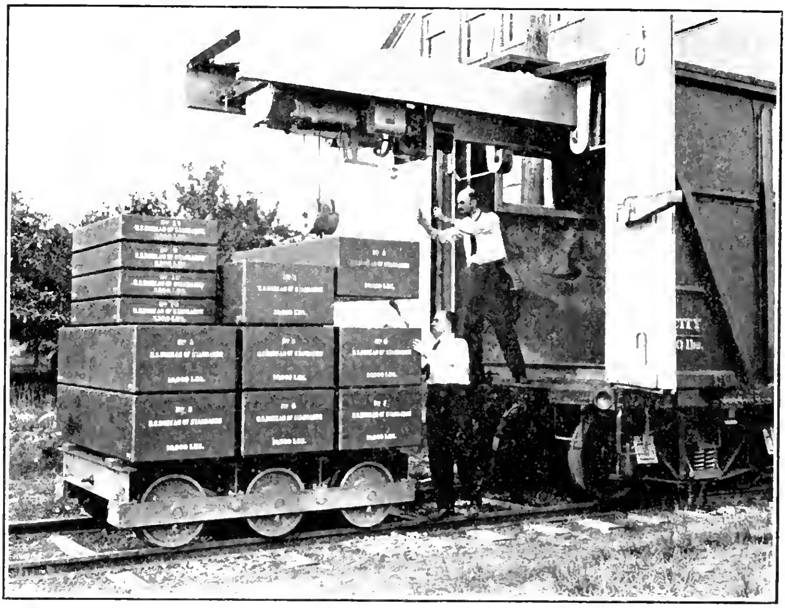
### *TRACK SCALE TESTING EQUIPMENT OF THE BUREAU OF STANDARDS*

About four years ago the bureau began to investigate the subject of railroad track and elevator scales with the idea of standardizing them. It soon became evident that the greatest diversity of opinion existed among the experts regarding these subjects and that there was very little reliable information on the subject. In order to secure reliable data, and to be in a position to test large scales upon the request of the railroads, elevators, shippers or state officials the bureau secured an appropriation of $25,000 from congress last winter to purchase an equipment and to provide the necessary expenses for its operation. This appropriation became available July 1, 1913. The equipment was completed October 1, and over thirty-five track scales were investigated in Connecticut, Vermont and New York during the following six weeks. Throughout this whole period the car met with every expectation and is ready for further tests.

The car designed by the bureau differs radically from those ordinarily used by the railroads. The usual test-weight car is a heavy compact steel body with four wheels and a base of approximately six feet. It may weigh from 25,000 to 80,000 pounds and has



Truck Scale Testing Equipment.



THE TRUCK LOADED WITH WEIGHTS.

to be standardized on a master scale of the capacity of the car. Also since the wheels, brake shoes, air-brake connections, etc., are part of the standard weight such a car must be constantly checked on the master scale. This equipment is satisfactory for a railroad where the hauls from the master scale to the scales to be tested is not great, or where the operations are restricted to a single state, but plainly such an equipment would not answer the purpose of the bureau since it expects to send the car to all parts of the country, and it would not be possible to establish the necessary master scales at enough points to insure the correctness of the test car. The car of the bureau was therefore designed to reduce the wear on the equipment to a minimum, and this is accomplished by carrying a specially built, short, six-wheeled truck, and 100,000 pounds of standard weights inside a box car which is equipped with the necessary power to operate a crane for handling the truck and test weights. The test weights consist of eight 10,000-pound, four 2,500-pound weights and ten thousand pounds of 50-pound weights. The total error of the eight 10,000- and the four 2,500-pound weights is less than half a pound and since the large weights are bolted down to the floor of the car in shipment from one scale to another and are very carefully handled when used, there is no reason why they should change appreciably in a year. The same is practically true of the truck, which may, in a test of a 52-ft. scale with three different loads, travel about 300 feet or about sixty miles in testing 1,000 scales. As this travel would be at a very low speed, and without the application of brakes or the accumulation of dust or mud, it is hardly conceivable that its weight will change as much as five pounds in a year, an amount that would be insignificant in the combined weight of the truck and test weights. The truck which is operated by an electric motor supplied with current from a gasoline engine generator in the box car weighs 5,059 pounds.

Fig. 1 shows the general arrangement

SIR DAVID GILL,
The eminent British astronomer, who has died at the age of seventy years.

of the equipment, while Fig. 2 shows a closer view of the truck loaded with seven 10,000-pound and four 2,500-pound weights, and the method of handling the weights.

In testing a scale the procedure is as follows: First, the box car which opens at one end is placed by a shifting engine five or ten feet from one end of the scale. Then the weights are unbolted, the gas engine is started and the crane is run out the open end about seven feet. Then the truck is picked up and set on the scale by the crane. This is followed by placing on the truck the necessary number of 10,000-pound weights to make up the desired first-test load. The truck is then moved over the bearing points of each section of the scale and the reading of the scale noted. The truck is run back to the original position and additional weights are added to make up the next test load, and the separate sections of the scale are again tested. This can be repeated until all the standard weights have been placed on the truck. If it is desired to go still higher the truck with its load of standard weights can then be run off the scale, the box car placed on the scale and weighed, the correction to the scale having been ascertained by the previous test. Knowing the weight of the empty car, the standard weights and truck can then be loaded, and the box car again placed upon the scale and weighed. In this way the scale may be tested up to approximately 175,000 pounds.

The general plan of the equipment is due to L. A. Fischer, physicist, Bureau of Standards, and to C. A. Briggs, assistant physicist, the whole being constructed by A. H. Emery, Stamford, Conn.

## *SCIENTIFIC NOTES*

We record with regret the death of Dr. Roswell Park, the distinguished surgeon of Buffalo; of Dr. George William Peckham, librarian of the Milwaukee Public Library, known for his contributions to entomology; of Dr. Edmund B. Huey, a student of genetic psychology, recently of the Johns Hopkins University, and of Mr. W. D. Marks, formerly professor of mechanical engineering at the University of Pennsylvania, later a consulting engineer in New York City.

Colonel William C. Gorgas has been appointed to be surgeon-general of the army of the United States, with the rank of brigadier-general.

The fourth annual award of the Willard Gibbs Medal, founded by Mr. William A. Converse, will be made by the Chicago Section of the American Chemical Society to Dr. Ira Remsen, of Johns Hopkins University. The previous recipients of this medal are Professor Svante Arrhenius, Professor Theodore W. Richards and Dr. Leo H. Baekeland.

Arrangements have been made for the establishment, as a memorial to Lord Lister in Edinburgh, of a Lister Institute.

The General Education Board has given $750,000 towards an endowment of $1,500,000 for the medical department of Washington University, St. Louis, to create full time teaching and research departments in medicine, surgery and pediatrics.

# THE POPULAR SCIENCE MONTHLY

APRIL, 1914


## FRESH AIR


By FREDERIC S. LEE

DALTON PROFESSOR OF PHYSIOLOGY, COLUMBIA UNIVERSITY


ON one of the hottest of the hot nights of British India, a little more than one hundred and fifty years ago, Siraj-Uddaula, a youthful merciless ruler of Bengal, caused to be confined within a small cell in Fort William, one hundred and forty-six Englishmen whom he had that day captured in a siege of the city of Calcutta. The room was large enough to house comfortably but two persons. Its heavy door was bolted; its walls were pierced by two windows barred with iron, through which little air could enter. The night slowly passed away, and with the advent of the morning death had come to all but a score of the luckless company. A survivor has left an account of horrible happenings within the dungeon, of terrible strugglings of a steaming mass of sentient human bodies for the insufficient air. Within a few minutes after entrance every man was bathed in a wet perspiration and was searching for ways to escape from the stifling heat. Clothing was soon stripped off. Breathing became difficult. There were vain onslaughts on the windows; there were vain efforts to force the door. Thirst grew intolerable, and there were ravings for the water which the guards passed in between the bars, not from feelings of mercy, but only to witness in ghoulish glee the added struggles for impossible relief. Ungovernable confusion and turmoil and riot soon reigned. Men became delirious. If any found sufficient room to fall to the floor, it was only to fall to their death, for they were trampled upon, crushed and buried beneath the fiercely desperate wave of frenzied humanity above. The strongest sought death—some by praying for the hastening of the end; some by heaping insults upon the guards to try to induce them to shoot. But all efforts for relief were in vain, until at last bodily and mental agony was followed by stupor. This tragedy of the Black Hole of Calcutta will ever remain as the most drastic demonstration in human history of the bondage of man to the air that surrounds him.

What is this thing upon which the life of the body is so dependent? As history goes, it is only comparatively recently that we have learned what air is. "To tell the story of the development of men's ideas regarding the nature of atmospheric air," says Sir William Ramsay, "is in great part to write a history of chemistry and physics." Believed at first to be a single substance, by the middle of the seventeenth century men began seriously to try to learn by means of experiment whether air is not compound. It would take us too far from our immediate subject to wander through the mazes of more than a hundred years of those early efforts, of the rise of the belief that air contains some ingredient that is necessary to both combustion and respiration, of attempts to identify this substance, of the contest between the phlogistic and the antiphlogistic theories, and finally of the rather rapid crystallizing out of the air's constituents. The credit of solving the problem belongs almost wholly to Englishmen. In 1755 Joseph Black isolated carbon dioxide, the first constituent of the air to be definitely recognized. Nitrogen was next to appear, the discovery of Daniel Rutherford in 1772; and two years afterward Joseph Priestley published the first description of oxygen. Here the matter rested for more than a century, when in 1895 Lord Rayleigh and Sir William Ramsay aroused the world by the announcement that they had found in air a new gaseous element in minute quantity, which they proposed to christen argon, the inert. To this Ramsay subsequently added the still more rare helium, krypton, neon and zenon, and he says:

> It would be rash to predict that no other elements still remain to be discovered among its [the air's] constituents; but if there are they must be present in still more infinitesimal amount than the rarer non-active gases.

We may, therefore, doubtless rest content with the thought that the problem of the air's constituents is practically solved and that, when pure, air is simply a mixture of gases, mostly elementary.

Air of ideal purity never exists outside the chemist's test tubes. The gases of atmospheric air are usually present in the following approximate proportions by volume:

| | Per Cent. |
|---|---|
| Oxygen | 20.94 |
| Carbon dioxide | 0.03 |
| Nitrogen | 78.09 |
| Argon | 0.94 |
| Helium, krypton, neon, zenon, hydrogen, hydrogen peroxide, ammonia | traces. |

As we know it and breathe it, air always contains other constituents derived partly from the inorganic earth, partly from plants and animals and largely from man and his works. Its oxygen is often diminished in quantity, its carbon dioxide often increased; it always contains the vapor of water in appreciable amounts, traces of nitrous and nitric acids, radio-active constituents, dust and usually bacteria; its composition may be altered by the presence of sea salts, by the respiration of man and other animals and plants, by the combustion of illuminating gas and its products, and by a host of industrial processes. Of these various alterations those produced by the respiration of man is of chief interest to us here. The gases of air as it comes out of man's lungs are present in the following approximate proportions by volume:

| | Per Cent. |
|---|---|
| Oxygen | 16.4 |
| Carbon dioxide | 4.1 |
| Nitrogen | 78.09 |
| Argon | 0.94 |
| Helium, krypton, etc | traces. |

Of the air's various gaseous constituents, nitrogen, argon and helium and its companions are what the chemists call inert substances, *i. e.*, they are slow and backward about entering into chemical alliances. However important nitrogen is in the life of living things, neither is it, nor are these other inert gases, known to exert as atmospheric components specific actions on living human beings. They may, therefore, be eliminated from consideration, as may also the minute traces of hydrogen and ammonia, and our attention may be focused at once upon oxygen and carbon dioxide.

With oxygen the case is very different from that of nitrogen. A component of all living tissues and a participant in nearly all vital processes, its one great source is the atmosphere, and its entrance into the human body is by way of the lungs in respiration. Without it man would perish; yet his body is so adapted that to sustain life permanently oxygen must be given to him in a certain percentage and under a certain pressure, both percentage and pressure varying within certain limits. Under the ordinary conditions of life the proportion of oxygen in the air that we breathe varies only slightly. Thus the air of the open country and that of the streets of crowded London differ by less than one tenth of one per cent. At the sea-side and on a mountain top 14,000 feet above, the percentage of atmospheric oxygen is practically the same; on the mountain top, however, the pressure of the gas may be less than two thirds of its pressure at the sea-side. Every inexperienced climber has felt the need of a greater pressure of oxygen. Archdeacon Stuck, when led by the indefatigable Karstens to the top of Mt. McKinley, suffered greatly from the rarefied air. Writing in the third person he says:

> The writer's shortness of breath became more and more distressing as he rose; all were more affected than at any time before, but none of the others in this acute way. The fits of panting became more frequent and more violent; at such times everything would turn black before his eyes and he would choke and seem unable to recover his breath at all. Yet a few moments' rest recovered him as completely as ever, to struggle on another twenty or thirty paces, and to sink gasping on the snow again. . . . With keen excitement we pushed on. . . . The last man on the rope, in his enthusiasm and excitement somewhat overpassing his narrow wind margin, had almost to be hauled up the few final feet, and lost consciousnes for a moment as he fell upon the floor of the little basin that occupies the summit.

Various experimental researches, and especially the latest and very careful investigation by Haldane, Douglas, Henderson and Schneider on Pike's Peak, have proved beyond a doubt that that formerly mysterious disease, mountain sickness, is due solely to the greatly diminished pressure of oxygen existing at all considerable heights. That wonderful power of adaptation to unusual conditions, however, of which the human body is so generously possessed, is here demonstrated in the fact that on reaching the unusual height the quantity of hemoglobin, which gives the red color to the blood and enables it to carry oxygen to our tissues, begins to increase, and a few days of life at the high altitude renders us capable of continuing to live there under the diminished oxygen pressure without further danger to life.

Within a crowded assembly the proportion of oxygen may fall to one twentieth of its usual amount in the outdoor air, probably never more except in the most extreme experimental conditions. Experimentation has apparently shown that the evil effects of such indoor air are not due in any respect to this slightly lesened quantity of the gas. It has even been diminished to less than seventeen per cent. in experimental chambers without apparent detriment to persons confined therein. Hill says of a group of his students whom he confined in a narrow air-tight room: "We have watched them trying to light a cigarette (to relieve the monotony of the experiment) and puzzled by their matches going out, borrowing others, only in vain. They had not sensed the percentage of the diminution of oxygen, which fell below seventeen." The ventilation of coal mines by air containing only seventeen per cent. of oxygen has indeed been suggested as a preventive of explosions. On the other hand, a "sand hog" working in a caisson at a depth of one hundred feet must be subjected to a pressure of oxygen four times that found in the usual atmosphere. Here he can work for several hours with impunity; a longer time would give an opportunity for the excess of this gas to manifest its toxic action on his tissues. Because of this poisonous action too, a man can breathe pure oxygen when in excess for a limited period only. The administration of oxygen in extreme illnesses thus has its limitations.

Ozone is a form of oxygen in which three, instead of the usual two, atoms are united in the molecule. It is present in minute quantity in the atmosphere, usually not of cities, but of the country and the sea. Its powerful oxidizing properties and its intemperate advocacy by enthusiastic but unscientific persons have caused it to be hailed popularly as highly beneficial to the human body, not only in ordinary respiration, but in the purification of the air of living rooms, the destruction of bacteria and other organic matters, and the cure of disease. On crisp cool mornings we are fain to enlarge our chests as we step into the open, and breathe in deep draughts of this supposedly health-giving gas; to mountain tops and forests we go in search of its renovating properties; and our mail is fat with circulars descriptive of the marvelous benefits of ozone machines, of ozonizers and ozonators. In many offices and homes we find these machines, busily at work discharging into the atmosphere their peculiarly odoriferous product. Very recent investigations, however, seem to make it clear that the supposed beneficial powers of ozone as a home companion are creations of the imagination. Two groups of American investigators, Jordan and Carlson in Chicago and Sawyer, Beckwith and Skolfield, in Berkeley, have independently carried out each a series of careful experiments on the action of ozone on bacteria, animals and human beings. They find that ozone will indeed kill bacteria exposed in a room, but only when in such concentration that it will kill guinea-pigs first.

> There is no evidence for supposing that a quantity of ozone that can be tolerated by man has the least germicidal action.

When present in any considerable quantity in the air ozone is irritating and probably corrosive to the lining membrane of the air passages of the nose, throat and lungs, causing the blood-vessels of this membrane to be excessively dilated and to present the customary symptoms of "sore throat." It causes headache and drowsiness. The heart, at first accelerated, is later slowed and weakened, and the pressure of the blood in the arteries is unduly lowered. The case for ozone thus seems to narrow down to a supposed beneficial action in destroying or modifying unpleasant odors in the air of a room. When in not too great concentration such odors are, it is true, overcome, though it is quite probable that their disappearance is due, not to an actual destruction of the odoriferous substance, but partly to a replacement of the disagreeable odor by the odor of ozone and partly to fatigue or anesthesia of the olfactory membrane of the nose. It is very questionable whether this is wise, and Jordan and Carlson well say:

> It seems to us that this is wrong in principle, and that ozone is being used and will be used as a crutch to bolster up poor ventilating systems. Ozone does not make pure air any more than strong spices make pure food.

Perhaps the last word has not yet been said on this subject; nevertheless I strongly suspect that ozone does not deserve the reputation which commercial interests are endeavoring to foist upon it and that as a panacea it is destined to follow into oblivion phylacteries and amulets, blue glass and the rabbit's foot.

Carbon dioxide within man's body performs certain useful purposes. Generated in all of his tissues and passed from his cells into the lymph and blood that bathe them, when in not too large quantity it reacts upon the tissues as a hormone, or excitant, to stimulate them to greater activity. It thus for a time, during the earlier stages of a task and before fatigue sets in, augments our working power. One of its most striking services is that of acting as the stimulus to that part of our nervous systems which presides over our respiratory movements. After each expiratory act the accumulating carbon dioxide within our blood excites our respiratory center to a subsequent inspiration, and except for this substance within us respiration would be impossible. But when in larger quantity than is required for these needs carbon dioxide is poisonous to our tissues, causing fatigue and depression of working power, and for the good of the organism must be expelled. It is, therefore, carried to the lungs and passed into the air. Thus much of the carbon dioxide of the atmosphere represents a waste and poisonous product of protoplasmic activities, of no use to man, however valuable it is to the green plants. When breathed in excessive quantity it may cause a feeling of suffocation, headache, nausea and other unpleasant sensations, and may ultimately even be fatal. But the poisonous properties of carbon dioxide have been exaggerated. Thus while normally it is present in free air in only about three hundredths of one per cent., the breathing for hours of more than thirty times this amount does not appear to be detrimental to the individual. In fact it has recently been shown by Crowder that the air immediately before our faces is contaminated with expired carbon dioxide in varying quantities which in extreme cases may reach one per cent. Except where ventilation is very vigorous, as in facing the breeze of an electric fan, we are thus habitually rebreathing a portion of the air which has previously entered our lungs. In the face of such facts the minute variations of carbon dioxide in unconfined air are altogether negligible from the hygienic standpoint. Thus the proportion of this gas is greater in the air of cities than of the country, in night air than in that of day, in fogs than in clear weather, with a low than with a high barometer, at the foot than on the tops of mountains, and inland than at the seaside. But all such differences amount to merely a few thousandths of one per cent. and are probably of no importance whatever in the life of the individual. There is a larger proportion of the gas in the more or less confined air of crowded assemblies, school rooms and industrial work rooms, but even here it very rarely reaches four tenths of one per cent., or ten times its usual amount, and this is still well below the harmful limit. It thus appears that carbon dioxide, like oxygen, may be eliminated from the problem of fresh air, except under the rarest and most extreme circumstances.

The amount of carbon dioxide present is often regarded as a convenient and proper index of the degree of vitiation of air by human beings, and a limit to this is sometimes established by law for factories where many employees work together. Our country unfortunately has not reached that stage of governmental control of its industries in which legal standards of ventilation are established and maintained. We ought to do this in the interests of the health of the workman, but when we are prepared for it we should select some other index of the air's impurity than the amount of carbon dioxide present in it.

There has long existed a belief—and it has been strengthened by the advocacy of competent men of science—that air that has once been breathed by human beings is poisonous apart from its content in carbon dioxide, and this belief has fixed upon a hypothetical unknown organic constituent, a toxic protein, which is supposed to be produced within the body, volatilized and then cast out with the outgoing breath. Various attempts have been made during the past twenty-five years to support this belief experimentally. The most of such experiments have consisted in condensing expired air, injecting it into animals and obtaining symptoms of intoxication. Notwithstanding their seeming conclusiveness one by one these apparently positive results have been explained on other grounds than as due to the presence of an expired organic poison coming from the lungs and, moreover, they have been offset by more conclusive experiments terminating negatively. The latest of these researches finds no evidence whatever to support the theory of an organic poison, a "crowd poison," as it is sometimes called; and we must believe that the theory represents one of those erroneous conclusions which science frequently draws from incomplete evidence and then proceeds to utilize in discovering the truth.

Another feature of vitiated air is odor. Odor is always due to the existence of material, in the form of either gas or very finely divided solid particles, which has the power of stimulating the delicate terminals of the olfactory nerves in the walls of the nasal passages. Pure air contains nothing that can stimulate these nerve terminals and therefore is wholly free from odor. Odor may be introduced into air through decaying organic matter, through illuminating gas or the products of its combustion, through various foreign substances used in industrial procedures, and through emanations from the human body. These last are many and varied, both in quality and origin, and together they give to the air of a crowded assembly which lacks adequate ventilation the peculiar unpleasant crowd odor with which all are familiar. Our sense of smell is subjected continuously to slight stimulation, but it is peculiarly and vividly responsive to unpleasant changes in our odorous environment. Thus on entering a crowded, close and stuffy room the odor often seems to us intolerable, and we at once assume that the air is very bad for any one who breathes it. We rush to the window and throw it open, or complain to the janitor, or retreat in disgust. Well, the air may indeed be very bad, but this is not because of its odor, except as to the odor's possible psychic effect. There is a peculiar relation between one's sense of smell and one's esthetic sense, and an unpleasant odor by rudely shocking the esthetic part of our nature may interfere with our efficiency; but there is no evidence in support of the idea that the odoriferous elements in crowd air are physically or chemically harmful to us. Our sense of smell, however it may disturb us, is probably the least valuable of all our senses in contributing to our physical welfare and it can the most readily be dispensed with—a too sensitive nose is really an affliction. This sense is in fact extremely subject to fatigue, and hence on confinement in crowd air our olfactory aversion to it soon ceases—a provision of nature which is not altogether an evil.

Strangely enough it is only within a period of scarcely more than thirty years that the occurrence and the significance of atmospheric dust have become accurately known. Dust has now been shown to exist in air everywhere: in uninhabited as well as inhabited regions, though the more where man and his works are; at the tops of lofty mountains; and over the largest of oceans. The numbers of dust particles found by different observers in a single cubic centimeter of air have varied from 157 at the summit of the Swiss Bieshorn to more than 200,000 in a Parisian garden. On dusty streets and within doors, especially in dusty trades, still more dust may exist, and it is estimated that a single puff of tobacco smoke discharges into the atmosphere 4,000,000,000 particles. Dust may consist of inorganic and lifeless organic matter, as well as bacteria and other living organisms. It may be carried long distances. The most striking known example of this is the fine pumice which was sent into the air to tremendous heights and in enormous quantities at the time of the extraordinary eruption of the East Indian volcano Krakatoa in 1883. This fine dust was carried completely around the earth and from the extreme north to the extreme south of the largest continents. Moreover, it continued to exist for several years as a component of the earth's atmosphere. To dust particles we owe the existence of clouds, fog and haze, the beautiful colors of the sunset, and in large part the blueness of the sky. Dust is thus our constant companion and with every breath we inhale much of it. Our bodies are prepared for this and possess defensive agencies for our protection. With these agencies in proper order the greater part of the ordinary inhaled dust is harmless. It is not so, however, with the dusts produced abundantly in various trades, such as in the manufacture of cutlery, pottery, porcelain, glass, copper, iron, steel, brass and lead wares, in stone-cutting and cotton manufacture. Some of these industrial dusts are poisonous; some are mechanically irritating to the walls of our air passages. In dusty occupations such diseases as bronchitis, tuberculosis and pneumonia are unduly prevalent, and there is no doubt that their beginnings lie in local injuries to the lungs produced by the inhaled particles and that these injuries are followed by the lodgment of the specific bacteria.

Of the bacteria of the air and their relation to disease I must speak at greater length. From the earliest times the belief has existed that bad air is a prolific source of disease. The word "malaria" literally means "bad air," and the disease malaria was the type of those diseases that were supposed to be spread through the atmosphere. In the early days of the germ theory air was regarded as the chief medium of the transmission of disease germs. As one writer graphically put it, disease is "literally borne on the wings of the wind." The great surgeon Lister accepted this notion and conceived the idea of improving surgical technique by maintaining a continual and very fine spray of carbolic acid in the air in the immediate vicinity of the operation. Thus antiseptic surgery arose. Although surgery has now gone far beyond this stage and no longer regards the air as a source of operative infection, the general notion of aerial infection still prevails. But a multitude of facts, gradually accumulated, show that this notion must be revised. It is true that bacteria may be moved through the air, and this may occur under three conditions: when they are freely floating, when they are attached to particles of dust, and when they are contained within the bodies of flying insects. The dissemination of disease germs by insects is a serious fact—the mysterious miasma of malaria lies only within the body of the mosquito, and malaria is still the type, but in a new sense, of certain diseases that are spread through the atmosphere. But there are many reasons for believing that the danger of infection through germs freely floating in air or attached to particles of dust has been much exaggerated. Living organisms, it is true, may be found in the atmosphere of inhabited localities under almost any circumstances. To capture them it is only necessary to expose to the air for a few moments a sterilized plate covered by a layer of nutrient agar on which the floating particles may fall. If the plate be then covered and transferred to a warm place, the organisms will proceed to multiply and develop colonies. It is then found that they comprise bacteria and some other microscopic forms. By far the greater number are quite harmless, but pathogenic or disease-producing species do occur. These may include germs of tuberculosis, diphtheria, typhoid fever, dysentery, anthrax and suppuration. The mere fact that such germs have at times been found, however, is of little significance in the matter of possible aerial infection. They never occur in any considerable numbers, and considerable numbers of germs are usually necessary to produce a disease. It is known that many bacteria on being cast out into the air from an infected source lose their virulence in the process of drying and soon die. Evidence that disease germs pass through the air from room to room of a house or from a hospital to its immediate surroundings always breaks down when examined critically. It is indeed not rare now to treat cases of different infectious diseases within the same hospital ward. The one place of possible danger is in the immediate vicinity of a person suffering from a disease affecting the air passages, the mouth, throat or lungs, such as a "cold," or tuberculosis. Such a person may give out the characteristic microbes for a distance of a few feet from his body, not in quiet expiration, for simple expired air is sterile, but attached to droplets that may be expelled in coughing, sneezing or forcible speaking. In this manner infection may, and at times probably does, occur, the evidence being perhaps strongest in the case of tuberculosis. But apart from this source there appears to be little danger of contracting an infectious disease from germs that float to us through the medium of the air—aerial infection in the most of those diseases with which we are familiar is, in the authoritative words of Chapin, "under ordinary conditions of home and hospital a negligible factor." Avoid all forms of physical contact with disease germs or germ-laden articles; keep hands and dishes clean; beware of infected food and water; if you can detect him shun the bacteria-carrier, he who unwittingly carries within his body the germs without the disease and may deposit them where subsequent physical contact is possible; but do not be tormented any longer by the unnecessary specter of germ-laden air.

I might add a few words concerning sewer gas. Sewer gas consists simply of air containing volatile substances which are given off by the decomposing organic matters that occur in sewage. There is nothing mysterious about the components of sewer gas except in the minds of those who stand in dire dread of it. It may contain carbon dioxide, the ill-smelling hydrogen sulphide and ammonium sulphide, marsh gas, ammonia and certain other gaseous substances—all of these in variable, and, with the possible exception of carbon dioxide, usually small amounts. There is no excessively poisonous gas among them. Bacteria exist abundantly in sewage, but these appear to be given off to the air only when the liquid sewage is mechanically splashed and then only in very small numbers and usually not to great distances. Winslow has made a most careful experimental study of this subject, and has come to the conclusion that "the chance of direct bacterial infection through the air of drains and sewers is so slight as to be practically negligible."

He says:

> If one were to breathe for twenty-four hours the undiluted air of a house drainage system, at any point not immediately infected by mechanical splashing, it appears that less than fifty intestinal bacteria would be taken in. . . . There would be less danger of contracting disease from continuously breathing the air of a vent pipe, except where liquid is actually splashing, than from drinking New York water.

Workmen in sewers are notoriously strong, vigorous, healthy men, with a low death rate among them. With such facts before us the specter of an invisible monster entering our homes surreptitiously from our plumbing pipes and sapping our lives and the lives of our children must be laid aside; we need no longer leave saucers of so-called "chlorides" standing about our floors to neutralize in an impossible manner mysterious effluvia that do not exist; and when we return to our town houses in the autumn we may enter them with no fears that we are risking our lives by coming into a toxic, germ-infected, sewer-gas-laden, deadly atmosphere.

Our consideration so far of the qualities of air and their relation to human beings has been mainly destructive. I have tried to make it clear that we must give up some of our long-cherished notions. We have seen that while air may be rendered unsuitable for respiration by very unusual means, such as the addition of poisonous gases or excessive quantities of irritating dust or bacteria, the vitiation of air by the presence within it of human beings is not due, except under the most rare and exceptional circumstances, to chemical changes produced therein by respiration, such that when the air is rebreathed it reacts harmfully through the blood on the bodily tissues. The claims that are sometimes made by the venders of commercial chemical air-purifiers on behalf of their machines are based upon entire ignorance of the facts.

Nevertheless, that the air of a confined, ill-ventilated room when crowded with human beings soon becomes bad can admit of no question, and we are forced to search further for its bad qualities. Science has in recent years apparently found them in the physical, rather than the chemical action of such air on the body. This conclusion has been reached, not so much through inability to find the evil in other features, as through the very positive results of many experiments made by different investigators.

The human body is constantly burning fuel within itself and producing heat in the process. The amount of heat thus produced during twenty-four hours by an average adult man, when at rest, is about 2,400 calories, which is equal to the heat evolved by four or five ordinary Tungsten electric lamps during the same time. Such a man doing hard physical work generates more than twice this amount. The heat generated within man's body is not wasted energy; it keeps his bodily tissues at the temperature (37° C.; 98.6° F.) at which nature has decreed that they shall do their best work. But more heat is produced within than is needed for this purpose, and if this excess were allowed to accumulate unchecked, man's tissues would very soon become unduly heated, the protoplasm of his living cells would become coagulated, and death would be the end of him. He possesses, however, a very efficient regulating mechanism by which his body is enabled to give off heat constantly and in quantity just sufficient to maintain an equilibrium, notwithstanding the varying amounts which he produces from minute to minute. This constant output of heat takes place partly through expired air, but chiefly by direct radiation into the air from the skin, by conduction from the skin to the clothing, and by the evaporation of perspiration poured upon the surface of the skin by the sweat glands. The skin is thus the medium by which the excess of the bodily heat is carried away. But the action of the skin is dependent upon the action of the nervous system in regulating both the amount of hot blood sent to it and the activity of the sweat glands. Whenever, therefore, the body works harder than before and produces more heat, not only does the breathing intensify, but through the nervous system the cutaneous blood vessels are dilated, more blood is sent to them, more perspiration is made in the glands, poured out and evaporated, and thus the excess of heat is passed out to the clothing and the air. By these provisions our bodily temperature is kept fairly constant, whether we do much or little work, whether we live indoors or outdoors, in summer or in winter, whether we labor beside molten metal at a temperature of 250° F. or are exposed to the polar air with its 75° F. below zero.

Nevertheless, it is obvious that there are external essentials to this physiological power of regulation and that these are the possibilities of the radiation and the conduction of the heat and the evaporation of the perspiration. The body is ever ready to do its share, but the surrounding air must be in such a physical condition as to supplement the body's activities. If the air be cool and moderately dry the best conditions exist for the body's well-being; if the air be hot and dry, or cool and moist, within certain limits the body can protect itself; but if the air be hot and at the same time contain much moisture a condition exists against which the body is imperfectly equipped. If the external temperature be as high as or higher than the bodily temperature, bodily heat can not be given out by radiation and conduction, and if at the same time the air be saturated with moisture, bodily heat can not be given out by the evaporation of perspiration; and thus with the two principal avenues of heat loss obstructed and with the fires still burning within, the temperature rises and the unfortunate individual passes into a fever. This fever is accompanied by abnormal chemical changes within his tissues and the production of toxic substances, which in turn react upon his tissues diminishing their working power, inducing early fatigue, and upsetting the normal equilibrium of his organs. The result of such a disturbance of his bodily mechanism, if very pronounced, is the production of a pathological condition which is called heat stroke.

But the extreme condition of air at a temperature above the bodily temperature and completely saturated is not necessary for inducing the pathological symptoms. We may witness them under somewhat more moderate conditions in the frequent cases of sunstroke which occur in the streets of our American cities on hot and humid days. The observations of Rubner, one of the foremost German hygienists, indicate that even at 75° F., or more than 23 degrees below bodily temperature and with a humidity of only 80 per cent. of saturation an untrained man can continue comfortable only by refraining from physical work. The performance of work under these conditions would throw a tax upon his powers of adaptation. Even at still lower degrees of temperature and humidity the unfavorable symptoms may begin to appear. indeed the point at which our environing air ceases to be comfortable and begins to force us to make special efforts at accommodation to it is one that is not outside our range of frequent experience.

Many experiments, some of them striking, seem to make it clear that it is to these two features of heat and humidity, the same features which are responsible for sunstroke, and not to others, that all the evil effects of the air of crowded, ill-ventilated rooms are actually due. These experiments have usually consisted in confining and observing men, perhaps several together, in comparatively small experimental chambers. Sometimes these chambers have been little more than bare boxes; sometimes they have been rooms provided with elaborate devices for varying the quantity and qualities of the air. Sometimes the subjects of the experiments have been obliged to breathe over and over again the same air; sometimes the air has been kept under careful control and changed in various ways. The effects of the various conditions have then been observed and recorded. These observations upon human beings have been supplemented by a variety of experiments on animals, and these animal experiments have added greatly to our knowledge of the qualities of the air which human beings ought to breathe.

One of the notable and fruitful investigations was an American one, carried on between 1893 and 1895 by Billings, Mitchell and Bergey with the aid of the Smithsonian Institution in Washington. The Billings of this investigation was the efficient organizer and first librarian of the New York Public Library and the Mitchell was our famous physician-author, Dr. Weir Mitchell. Another helpful American contribution is that of Benedict, whose work with the respiration calorimeter at Wesleyan University was so prophetic of worthy contributions to science that he was chosen to organize and direct the work of the Nutrition Laboratory of the Carnegie Institution, which is situated in Boston. The Germans, as ever, have also been leaders in this experimental work, an important contribution having come from the laboratory of Professor Flügge of Breslau. The English have been and are still contributing some of the most significant facts, especially a group of men led by Dr. Haldane of the University of Oxford. The work of Dr. Leonard Hill of London has become widely known through the public prints. The eminence of these various men is indicative of the interest which the homely subject of fresh air can arouse in us.

Several of the investigators have placed men within small closed experimental chambers, arranged with tubes passing through the walls to the outside air, so that the subjects within can at will rebreathe the hot, close, confined air or take in the fresh air from outside. Under such conditions it is found that confinement within and breathing of the unventilated air soon brings on the usual symptoms. If the subjects then breathe through the tube the fresh cool air from outside they obtain no relief. If they step outside relief comes instantly. If, on the other hand, a person standing in the fresh air outside breathes through the tube the stale air of the chamber, which has been breathed over and over again by the subjects within, the unpleasant symptoms do not appear; if he steps inside, they begin to appear at once. If with subjects within feeling the ill symptoms electric fans be started and the stale air be vigorously stirred, thus driving the hottest air away from the skin, relief comes at once. These fundamental experiments have been performed in varied ways, and have been supplemented by many others. Their results have accorded well with one another and allow but one general conclusion, namely, that the evil effects exerted upon human beings by air that has become vitiated by human beings result not from a lack of oxygen, not from an increase of carbon dioxide, not from the presence of an organic poison, not from any chemical features of such air acting through the lungs on the tissues, not in any manner from the rebreathing of such air, but solely from the physical features of excessive heat and excessive humidity interfering with the proper action of the skin in regulating bodily temperature. The problem of bad air has thus ceased to be chemical and pulmonary, and has become physical and cutaneous.

With this knowledge before us it is clear that in the ventilation of the future attention should be focused less upon the chemical purity of air, although of course there are ultimate limits to chemical purity, and more upon the maintenance of a physiologically proper temperature and humidity. What here constitutes physiological propriety varies with individuals, with age, with clothing, with occupations and with habit. Undoubtedly our American houses during the winter months are usually kept too hot to maintain the highest efficiency of the individual. We are in far better physical condition when surrounded by a house temperature of 65° to 68° F. than of 70° F. Some of the British authorities advise a house temperature as low as even 60° F. Young persons can live efficiently in a lower temperature than those of middle life, while aged persons require warmer air. A lower temperature is better where physical work is being done. The following temperatures of heated rooms are recommended by American ventilating engineers:

| Occupants at Rest | Degrees F. | Occupants Physically Active | Degrees F. |
|---|---|---|---|
| Living rooms, offices, schools... | 68 | Gymnasiums ................ | 60 |
| Lecture halls ................ | 61–64 | Work shops, moderate exertion. | 61–64 |
| Sleeping rooms ............. | 54–59 | Work shops, vigorous exertion. | 50–59 |
| Bath rooms ................. | 68–72 | | |

As to humidity, a percentage of 60 with air of 68° F. is rational. But the amount of moisture that air is capable of absorbing varies greatly with the temperature, hence it is impossible to establish a single standard of humidity that can apply to a range of temperatures. The surest single index of the physiological quality of the atmosphere at any moment is the reading of the wet-bulb thermometer. In this thermometer the bulb is covered by thin muslin or silk soaked with pure water. The evaporation of the water cools the bulb. The position of the mercury in such an instrument depends on two factors: first, the temperature of the air; and secondly, the amount of evaporation of the water immediately surrounding the bulb, which in turn varies inversely with the amount of moisture in the air generally—the more moisture in the air the less evaporation from the bulb. The wet-bulb thermometer is thus an index, at once, of both temperature and humidity. The most efficient simple instrument for the determination of humidity is the combination of dry bulb and wet bulb thermometers known as the sling psychrometer, but a fairly satisfactory indicator for household use is the instrument sold commercially under the name of hygrodeik. For our living rooms a wet-bulb reading of 60° F. is favorable to the maintenance of a comfortable and efficient physiological state. We can usually keep the temperatures of our rooms within reasonable limits by the aid of our heating systems and air admitted through windows; but the humidity can not be so perfectly controlled without more elaborate means than most private houses are provided with. With the increase in size of our American buildings, whether apartment houses, office buildings, school houses or factories, the provision of ventilation by means of more or less elaborate apparatus has become a necessity, and the profession of heating and ventilating engineer has become one of dignity and importance.

If I were to add to this lecture a paragraph of practical hints, I would say, first of all, keep your houses and offices cool, never above and usually well below 70° F. Unfortunately here a difference between men and women sometimes causes trouble. Woman possesses a perpetual blanket of adipose tissue between her skin and her muscles, which is usually less developed in man, and hence women can dress more thinly than men, and are usually comfortable at a lower temperature. I have seen more than one happy home in danger of wrecking from this unfortunate difference. As a married man I am tempted to plead for greater charity on the part of wives; as a physiologist I realize that a lower temperature is more healthful. Keep room air in motion. An electric fan or a current of air from a window is a great aid in keeping down one's bodily temperature, and preventing sleepiness and bodily discomfort from stagnant air; with electric fans in use there would be fewer naps in churches and lecture halls. Air in motion promotes efficiency. Accustom yourselves to draughts, and especially big draughts. A small blast of cold air directed against a small area of warm skin may do harm, but the larger the current the more the harm gives way to benefit. Air of constantly uniform temperature is monotonous and debilitating. An occasional and considerable cooling, a flushing of the room by a sudden large inrush of outside air is, like a cold bath, stimulating. Do not be afraid of opening the windows of sleeping rooms at night. The prejudice against night air, which arose naturally enough from the belief in the existence of nocturnal disease-bearing miasms, in the light of present knowledge is a foolish prejudice and must give way to the rationalism of scientific fact. The increasing employment of cool outdoor air both night and day as a therapeutic agent in the treatment of disease is based on scientific principles and is justified by its results. And, finally, the whole moral of the modern physiological doctrine of fresh air may be expressed tersely in the two short words, keep cool.

I have thus endeavored to present to you a fair picture of the present attitude of science toward the problem of fresh air and its relation to health. Such a consideration affords an unusually fruitful opportunity to witness the ways in which science progresses, forming hypotheses, testing them and then retaining, rejecting or refining them, as the evidence derived from observation and experiment warrants. Of the subject before us there are still many gaps in our knowledge, and these gaps must be filled. Present knowledge is never final, and our present ideas of what constitutes fresh air may yet require revision. There has recently been brought together in the City of New York under the influence of the Association for Improving the Condition of the Poor and with governmental recognition a group of representative men of science constituting the New York State Commission on Ventilation. These men are keenly alive to the many interests involved in the general problem of air in its human relations and are now beginning in this city an extended experimental investigation of them in the hope of obtaining results of value to both science and humanity. The man of science who thus successfully investigates feels the keen and satisfying joy of pushing back a little farther the barriers between the known and the unknown; and the multitude who look on reap a benefit from his labor in seeing pointed out a way to more healthful living.

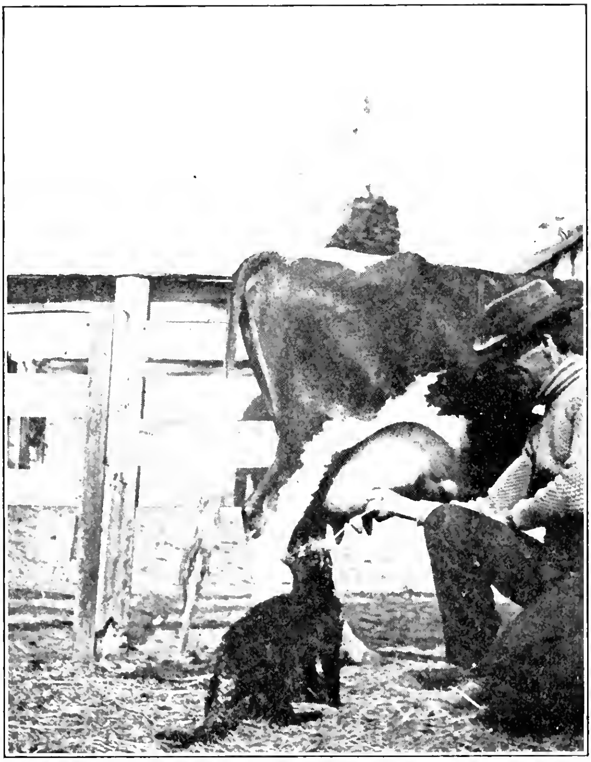
# NATURE-PLAY

By CHARLES LINCOLN EDWARDS, Ph.D.
DIRECTOR OF NATURE-STUDY, LOS ANGELES CITY SCHOOLS

CHILDREN have a natural interest in all things that are alive, and especially in such comrades as the dog and cat. The nature-study that does not appeal to this interest is worthless. Without formal lessons and examinations and stimulated only by the spirit of play, the child may get an understanding of the other animals that live in the world about him. This is a recreation subject, with the world for its playground; wherein a deep-lying sympathy, bred through the ancestral ages of growth near to the heart of nature, shall lead the child into the joy of living and the happiness of love and knowledge. Nature-play, rather than nature-study, is the key to this wonderful fairyland, of which the child is a part.

In the elementary schools, there should be the freedom to teach and the freedom to learn which have always distinguished the universities of Germany. The mechanical prescription of certain conventionally accepted studies for all pupils, without regard to their individual natures, should be replaced by courses adapted to the constitution and needs of each mind. The individuality of the human being must be recognized and respected in the grammar-school grades as well as in the kindergarten, high school, college and university. The teaching of all subjects by the one teacher in the primary grades should give place to leadership by specialists, as it has already in the secondary schools and colleges. The success of such departmental instruction in many schools justifies its universal adoption.

As in the Heimatkunde of the German schools, a knowledge of nature begins with the investigation of the geography and natural history of the home and its neighborhood. Every child, when led by curiosity and interest, is an investigator, and the discoveries made constitute the most important part of his education. Through open eyes the child should see the common things about him; and then through imagination he may visit distant lands. The domestic cat is quite as interesting and important as the Siberian tiger. At first, the child thinks he knows all about his common playmate, the cat; and yet, he is ignorant of the most significant fact: of the relationship of the cat to himself and other animals. By the simple process of feeling the top of his head, and looking at the back of his hand, he is brought to realize that he, as well as his cousin the cat, belongs to the fur-bearing animals. He learns that the cat walks about on two hands and two feet, and does not have four feet, as he has hitherto believed. In addition, the cat, like himself, has two eyes, one nose, one mouth, two ears, a heart, lungs, stomach, and, in all respects, is built very much like a human being. After fellowship in play, the child becomes conscious of the most important fact of all: that the cat is intelligent and, in addition to feelings and instinctive actions, has a sense of humor, malevolent and affectionate emotions, thinks and reasons, not indeed with a human mind but with a cat mind. After this, the boy is not so apt to throw a stone at the cat, for he may hit his cousin. He now begins to distinguish the



Three Cousins.

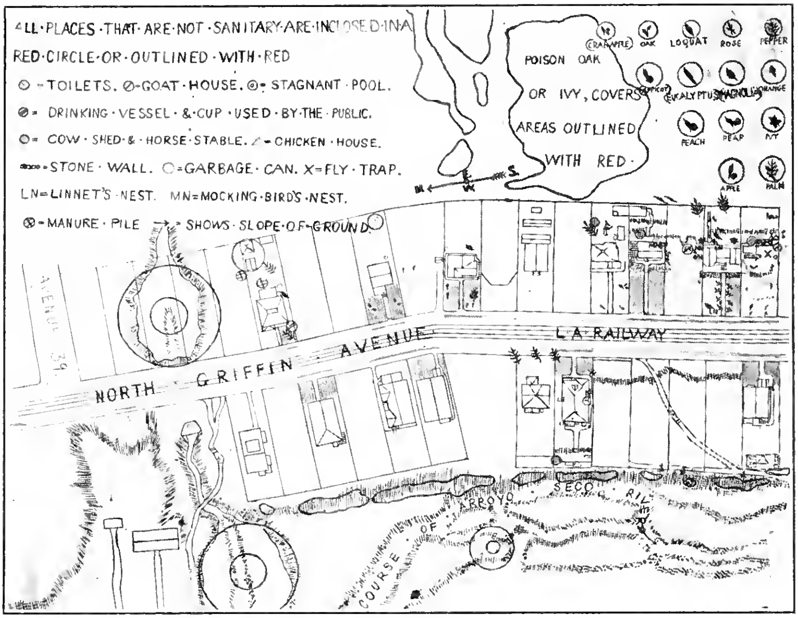
animals who are his friends, to be loved and protected, from those like the fly, who are his enemies, to be eliminated. While learning to love nature, the child should not be influenced by a sickly sentimentality, which prefers to allow flies to live rather than the little babies whom these dangerous animals infect with disease germs.

In our nature-play, one type of animal, or plant, or a few closely related forms, is taken for each week. The course comprehends more than the interpretation of the structure and behavior of the isolated types. The relationship to one another, and to the child, of these living

Children Playing with Dogs.

things, is of the greatest consequence. The underlying philosophic basis of comparative anatomy and physiology is kept in mind in the selection of the series of types. There is a necessary dependence upon the season for the observation of many of the plants and animals examined; yet the course should never lose its general theme and become a desultory consideration of unrelated forms. Always freeing the descriptions from unnecessary technicalities and Latin names, the more notable facts are presented in such form, that all children may comprehend them. In the

Observation at the Live-box.




SANITATION MAP BY ALBERT KING, SIXTH GRADE, AWARDED FIRST PLACE IN THE WOMAN'S BULLETIN COMPETITION OF 1913, LOS ANGELES CITY SCHOOLS.

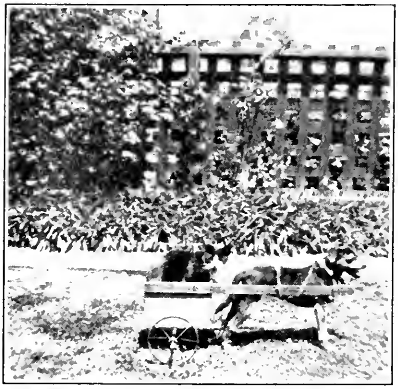
beginning the familiar domestic animals are taken; in order that nature-play, started in the school-room, may be continued after school, about the home. A new interest is aroused in the cat, dog, chickens, horse and cow, in the fly and ant, as, led by the teacher's suggestions, the child investigates and is thrilled with new discoveries. Then the pupil is prepared to learn of the less accessible creatures of woodland and sea-side.

When the school program prevents excursions into the field, to parks and museums, the part of nature being investigated must be brought into the school-room. Animals, like the cat, rabbit, chicken, lizard, toad, insects and many others, may be kept in live-boxes, one of which should be provided for each school-room. The best of these live-boxes, or cages, are those planned and constructed by the children themselves. In such efforts, a cooperation with the manual-training department is desirable. By the insertion of a screened door and windows, any dry-goods box may be transformed into the temporary home for the visiting animal. Elaborate and expensive apparatus is not necessary. A glass preserving jar makes a good aquarium for fish or tadpoles. Just as in any other play, children may be relied upon to invent and build the simple things needed.

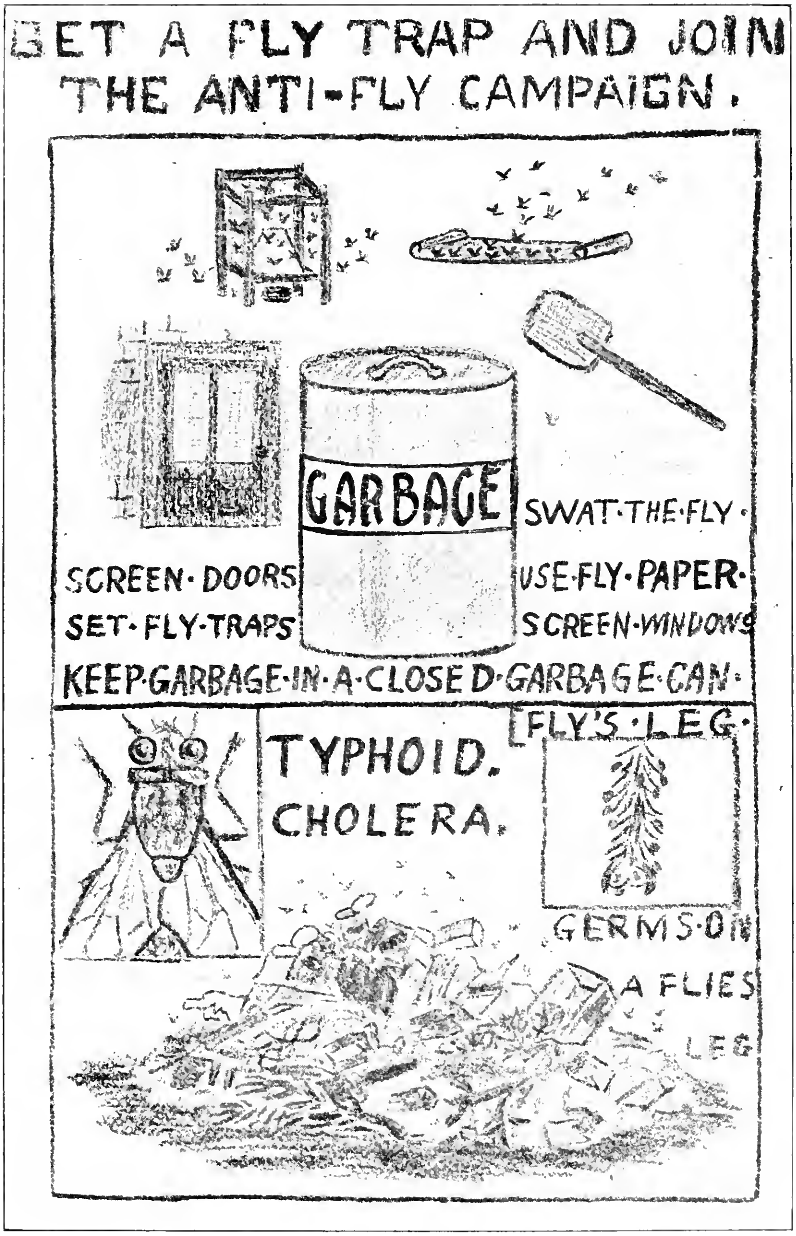
Never tell children that which they may find out for themselves. Let them count the fingers on the hand of the cat, and then the toes. Have the children watch the activities of the ant nest and then tell the story of their observations in the school-room and at home. In this way the child develops initiative, resourcefulness and the power of expression, while others share in his interesting knowledge and discoveries. The child himself and his development is the chief aim of nature-play.

At least ten minutes each day should be given to the type under consideration, with an appropriate subdivision of the subject matter for the week. There is no need of different subjects for the various grades. There is not a first-grade cat, second-grade cat, and so on; but only the one cat which should be described in such clear and simple language as to be readily understood by pupils of all ages. Each teacher may be trusted to make whatever translation, or omission, if any, may be necessary for her own pupils. Both teachers and pupils should freely ask questions of one another. If no one knows the answer, let all together become searchers for truth. The crime is not to be ignorant, but to pretend to knowledge when ignorant. With the same type in all the grades, children of different ages in the same family, or neighborhood, and their parents, as well, may all join together in nature-play and thus the larger part of the population will be devoted to learning all about the type in hand. Thus movements for civic betterment, such as the campaign against the fly, may be organized and promoted with power and efficiency.

As a record of individual observations, nature maps may be made of much value and at the same time give an inspiring opportunity for practise in drawing. On a large sheet of paper, the pupil lays out his home square, bounded by streets and subdivided into lots. Houses, stables, trees, bushes, cats, dogs, rabbits, horses, cows, chickens and other birds, lizards, toads, ants and other insects—indeed all the works of nature and of man that it is possible to include—are drawn in, or indicated by appropriate symbols. The sanitation map is a modification, showing



Photograph by Herbert Mooney, Fifth Grade, Awarded the First Place in the First Annual Nature-study Exhibition of the Los Angeles City Schools.




Prize Poster by Albert King, Sixth Grade, in the Nature-study Anti-fly Campaign, Los Angeles City Schools.

all unsanitary conditions such as piles of stable manure and other filth where flies breed, and stagnant pools harboring mosquito larvæ. An accompanying explanation indicates the remedial work to be done in order to make the region a sanitary place of residence.

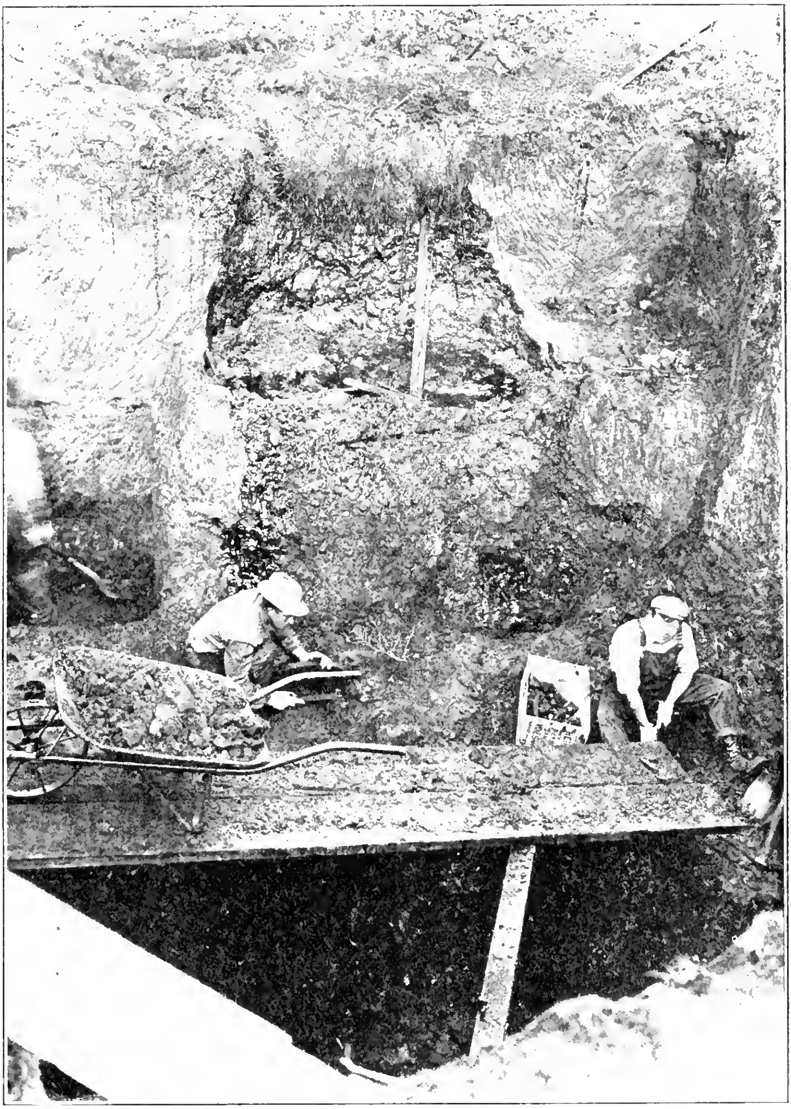
The nature map may be made the basis for a knowledge of economics, by showing: (1) the gardens and the value of their products; (2) the utility of common garden animals—like the toad, lizard, and spider—who eat destructive insects; (3) the proper development of the unused ground.

At the general annual exhibition of nature-play, prizes are offered for the best nature map, poster, drawing and photograph, and this recognition of their work encourages the pupils to sketch and photograph from nature.

The collecting instinct of children should be stimulated and directed toward the gathering of insects, rather than birds' eggs, of feathers, flowers, leaves, rocks, soils and other objects which do not rob nature of things beneficial to man. In this manner, each school-room may build up a useful museum of natural history. To promote the zeal of the young naturalists a nature club is organized in each school. A congress of these clubs is held every month, when the Director gives an illustrated lecture upon some topic of current interest. Agassiz's advice, to "study nature, not books," is important above all things, and yet it must be recognized that a knowledge of the records of the observations and investigations of others makes it possible to see and understand nature more clearly. It is useful to have a library in each room, with books and pictures concerning natural history.

The chief thing is to bring the child in contact with nature, and to give him the pleasure and stimulus of original discovery. It is desirable to have excursions into the yard, garden, field and forest whenever possible. While the class may not visit other countries and thus become familiar with foreign animals and plants in their native environment, yet good zoological parks and botanical gardens offer an excellent, although limited, substitute. After learning of the cat, at school and at home, the pupil may profitably see the large cats, like the lion and tiger, in the zoo, or in the wandering menageries. Almost every child has been to the circus and experienced one of the best possible nature excursions. The giraffe, camel and elephant have been so carefully observed that the pupils are able to sketch them. The child should learn why the giraffe has a long neck and spots on his brown fur, how the camel stores up food in his humps and water in the sacs around his first two stomachs, of the varied uses of the remarkable trunk of the elephant and of the animal's high intelligence.

In order to thoroughly understand things that live to-day, the history of the transformation of their race upon the earth must be followed.



Excavating in a Rancho La Brea Fossil Bed. At a depth of ten feet, a nest of bones yielded the remains of a bison, two lions, a wolf, horse and other animals. Photographed by L. E. Wyman, through the courtesy of Frank S. Daggett, Director, Museum of History, Science and Art.

The child, learning that the horse walks on the tips of the middle fingers and the middle toes, becomes fascinated with the story of the evolution of this animal, through thousands of generations, from a small mammal about the size of a dog, which had five fingers on each hand and five toes on each foot.

In our excursions to the asphalt fossil beds of Rancho La Brea, down in the pits the pupils see the embedded skulls and teeth of the imperial elephant and of mastodons, and the bones of saber-toothed tigers, lions, wolves, sloths, giant oxen, camels, and many birds. Here too, beside the trunk of a large cypress tree, a human skeleton has just been found, its bones intermingled with those of the giants of the past. It is not yet determined whether this rare discovery will antedate the earliest remains of man previously recorded. We may then more vividly realize how these strange creatures roamed over our mesa several hundred thousand years ago. These bones have been as perfectly preserved by the infiltrated tar, as if from animals only recently dead; and in the county museum we observe with delight the rare collection of their mounted skeletons. Frequently some bird, deceived by the brightly reflecting surface of a tar pool, alights and is drawn to death and burial in the sticky tar, thus repeating the story of the ages.

Another story from this wonderland of ancient days is added in that of the gigantic reptiles of the past, like the thunder lizard, twice as long as the school-room and so tall that its back-bone would go through the ceiling. The toothless hen, with arms as wings, adapted to flight, a rudimentary free thumb, and the other fingers fused into one piece, has descended from the first bird, with many teeth, three free clawed fingers and a long lizard-like tail having a row of feathers on either side. The ancestor of the first bird was a reptile with five fingers on each hand and five toes on each foot.

Looking Down into a Rancho La Brea Asphalt Pit, to a Depth of Ten Feet. To the left; skull, femur and jaws of the imperial elephant. To the right; below, femur and teeth of mastodon and femur of giant ground sloth; above, tar seepage through side wall. Photographed by L. E. Wyman, through the courtesy of Frank S. Daggett, Director, Museum of History, Science and Art.

FOSSILS IN RANCHO LA BREA DIGGINGS, SHOWING RICHNESS OF DEPOSIT. Copyright 1909 by J. Z. Gilbert and F. C. Winter and reproduced by their permission.

The history of the modification of some of the earlier water dwellers for life on dry land is illustrated in the development of the tadpole into the toad. The vegetarian tadpole, breathing air dissolved in the water, gradually absorbs its gills and propeller tail and sprouts arms and legs, in order that as a carnivorous toad it may hop about on land and breathe through its newly acquired lungs.

Many living things are useful to man and many are apparently useless, many are beneficial, and many harmful, and yet a knowledge of all nature is to be desired. Pasteur, in his earlier studies of wild yeasts, did not dream that ultimately his work would lead to saving the silk and wine industries of France and reducing the mortality from hydrophobia to less than one per cent.

The child learns that germs are not bugs, nor worms, nor little devils, but that they are very minute plants. When one says he does not believe in germs, he should also say that he does not believe in mushrooms; for both are related plants, the main difference being one of size. It is vital to know that while some germs produce disease, others are the best friends of man. The surface of the earth would be piled sky high with the dead bodies of plants and animals, if not for the putrefactive germs which produce all decay. The green plants, and in the end the animals, too, would starve, if not for certain soil bacteria which fix the nitrogen of the air in the form of the simple food necessary for plants. To germs must be given the credit for the delectable flavors of butter and cheese, and of assisting, if not being absolutely essential, in the processes of digestion.

To develop narrative skill we have introduced a game called caravan. Beginning in one of the rooms of the upper grade, the teacher selects three pupils especially interested in nature-play, each to describe some animal from the course. The name of the creature is not to be given by the narrator, but must be guessed by the others. Contrary to most guessing games, the object is to have given such a lucid description that the name of the animal will be guessed very soon. Then every one is invited to add anything not mentioned, or to correct any misstatements; so that the descriptions may become the general contribution of the room. By a majority vote the animal is selected to represent the room in the caravan, and then in a similar manner the pupil who can best describe the selected animal. Thus, the caravan starts on its way, in each room, adding a new animal after those already in the caravan have been described. The game proves an admirable review, in which each participating mind is keenly stimulated by the spirit of competitive play.

When man first became superior to the other animals he used weapons to kill them with. The vestige of that primitive struggle for existence is found now in hunting, sometimes necessary for the supply of food, but generally indulged in as a "sport." One summer day,

A Ground Owl that Mistook a Rancho La Brea Pool of Tar for Water. Vegetation on bank reflected in pool. Copyright 1909 by J. Z. Gilbert and F. C. Winter and reproduced by their permission.

A Nature Club Collecting Insects.

beneath the pines at the Alpine Tavern on Mount Lowe, the gray squirrels came to eat nuts from my hand. They had learned to love and trust men. A few months later a hunter approached the boundary of the reservation. The squirrels saw man, their friend, and ran toward him,

Collecting in the Pools.

happy in the expected reward, only to receive shot instead of nuts and to fall dead at the hunter's feet. Another day, near the foot of the western cliffs of San Clemente Island, a great dead sea-lion was floating on a mass of kelp. The Japanese fisherman said that, the day before, sportsmen had shot the sea-lion for the "fun of it." The call of the wild is a tempting voice, leading men back to nature. May the day come soon when many will respond to that call, but with the substitution of camera for gun, yielding better sport and in the end saving our fast vanishing native animals. Just as condemnable as killing animals for sport is the fashion which demands the slaughter of birds for their feathers. The story is familiar of how the beautiful plumes are taken from nesting egrets, and thus the millinery hunters not only kill the

Children at the Tide-pool.

parents in large numbers, but also leave the young birds to starve in the nest. Women who do not desire to share in such wanton destruction of bird life will adorn their hats with feathers from the ostrich and other domesticated birds, or with artificial flowers and ribbons.

The poetic insight is necessary for creative work in science as well as in literature. This gift enabled Darwin to construct a philosophy of nature, and Browning to portray the human heart, while in Goethe it was common source of inspiration for naturalist and poet. The imagination of the child should be cultivated, not suppressed. He should hear voices singing in the winds and hold communion with the dryad of the whispering woods and the Naiad of the babbling brook. The stories and songs of negroes and Indians, as gathered in books of folk-lore, con-

Seaside Collecting.

stitute a helpful adjunct to nature-play. These more primitive people are but grown up children, living in that closer touch with nature often forbidden the dwellers in brick apartments. The beginnings of romance are found in the thrilling adventures of "Brer Rabbit" and the contest of "B'Helephant and B'Vw'ale." Such mythical tales as "Why the Bat is Blind" and "How the Animals Secured Fire" are among the first fanciful attempts to account for natural phenomena. Boys and girls are at home with the ant people, while these intelligent and industrious creatures transport and care for their young, hunt their enemies, cultivate their aphid herds, or fill their subterranean granaries with the seeds which the workers have harvested. We shall not deny mind in the ants simply because they do not perceive and think just as we do. It is quite as efficacious to touch and smell at the same time, through antennal end-organs, as to have these functions separately performed through fingers

Children on the Rocks at Low Tide.

and nose; and it is also just as well to hear through the vibrations of the earth as through those of the air. Because ants remember odors, they are able to distinguish between friends and enemies, and the observant child may learn that the ant people get angry, at times are afraid, dislike some things and are fond of others, and show sadness and joy, hatred and love.

One of the principal elements in human happiness is the realization of beauty in nature, whether it be in the exquisite form and color of the petal of a rose, the glowing green of the beetle's armor, the flight of the swallow, the moonlight serenade of the mocking bird, the iridescent green and bronze ocelli of the peacock's tail-coverts, the mountains veiled in opalescent mists, the abysmal blue of the ocean, the glory of red and gold in the sunset, or the shimmer of the myriad stars. There is a beauty of structure and function, as in the system of lenses which focus upon the retina the countless rays of light from objects near and far, and thus make possible the mental perception of beauty in nature.

Consider the adaptation for dispersal shown in the dandelion, when the baby plant, in the seed, surrounded by food and borne aloft by a delicately tufted aeroplane, floats far away from its mother. Somewhere—if it fall on fertile soil—when the weather is propitious, the baby dandelion will awaken, sprout as a seedling, mature into parenthood and in turn provide food and aeroplanes for its children.

Nature-play is the true basis for all knowledge. Through this dominant interest the child is led to know of the living things about him. Not merely are the facts of nature important, but much more valuable is the fascinating story of how and why these facts came to be. It is of much import to learn that the animals which bear scales and those covered with feathers, or fur, are all wearing similar clothing, but of the different fashions best suited to their needs. It is still more significant to realize that fundamentally the minds of all animals are as allied as are their digestive and respiratory systems. The great end of nature-play for the child is not simply to learn of the rest of nature, but better to know himself as a part of nature.

# RECENT DEVELOPMENTS IN WEIGHTS AND MEASURES IN THE UNITED STATES

By LOUIS A. FISCHER
BUREAU OF STANDARDS

DOUBTLESS many of the readers have noticed in the newspapers and magazines during the past few years articles on false weights and measures and their effect upon the high cost of living; and have wondered why false weights and measures should exist. A more intimate knowledge of the subject will, it is believed, increase that wonder rather than diminish it, for does not the government maintain standards of weights and measures and do not the statute books of the states contain laws purporting to enforce their use? While almost any one will admit the necessity and the importance of regulation if his attention is called to the matter, it is a singular fact that it is only recently that any general interest has been manifested in the subject, or that there has been any organized movement to improve and enforce the laws in regard to weights and measures.

The founders of our government evidently realized the necessity of uniform standards or they would hardly have provided for it in the Constitution in the same clause that gives Congress the power to coin money and to regulate the value thereof. Under that authority the government coins all money, and enforces the severest penalties for counterfeiting. On the other hand, it has enacted practically no weights and measures legislation, but has left the question entirely to the states.

Even the pound, yard, gallon and bushel in common use have never been adopted by Congress, but owe their use to the fact that the government uses them in the collection of revenue and to the fact that they have voluntarily been adopted by the states.

Shortly after the establishment of the Bureau of Standards, complaints began to be received from individuals who felt that they were not receiving all that they were entitled to, and inquiring what they could do about it. There being no federal laws, the bureau could only advise them to look to their state or local authorities for assistance, although it was well known that none of the states at that time had an adequate system of inspection. It soon became evident that the states would not act of their volition, and equally evident that Congress felt no responsibility in the matter. The complaints were scattered, and those suffering were unorganized and consequently without influence. The railroads, corporations and organized industries, like the grain industry, were able to establish and maintain their own weighing or inspection department, but the individual of the middle or poorer classes had to take what was offered to him or else go to court with every prospect that he would lose his case on some technicality.

In 1902 the writer visited several of the larger cities in the State of New York for the purpose of ascertaining how efficient the inspection service was. The results were discouraging: in most places the inspectors were paid by fees for sealing the apparatus and, consequently, they were only interested in sealing the apparatus for which they could collect fees. They cared very little whether the apparatus was correct when examined, and still less whether it was properly used afterwards. New York City had ten sealers, at $1,200 each, and ten inspectors, at $1,500, under the city clerk, but most of them did little else except draw their salaries. The writer called upon one of them about ten o'clock in the morning and found him still in bed. His young child was playing with his standard weights, which he quickly took away from him when the object of the visit was explained. He frankly admitted that he owed his appointment to his political activity and that little or no services were expected of him.

The situation in New York was no worse than in other sections of the country, as we afterwards found out; it was merely typical of the conditions that existed throughout the country at that time. A couple of years later, or in 1904, the bureau conceived the plan of inviting those officers in the states who were by law charged with the custody of the state standards, to meet in Washington to study the weights and measures situation, and to ascertain what steps should be taken to insure some measure of protection to the public. The first meeting took place in January, 1905, and was, it is believed, the first meeting ever held in this country for the purpose of considering this subject. Pennsylvania, Michigan, Kentucky, New Hampshire, Vermont, Massachusetts, Virginia, Iowa—in all eight states—and the District of Columbia sent delegates. The governors of many of the other states showed interest in the matter, but stated that on account of the lack of available funds from which the expenses of the delegates could be defrayed it would be impossible to have their states represented. Nevertheless, the delegates who did attend were greatly interested in the subject and requested the bureau to arrange for similar meetings annually. Many of them did not know that they had any laws to enforce or any standards to take care of until their attention was directed to the state laws on the subject by the bureau.

Meetings have been held every year since, but the number of states represented never exceeded seventeen until 1912, when 25 states and 34 of the most important cities, including the District of Columbia, were represented. What the earlier conferences lacked in numbers, however, they made up in enthusiasm. By conferring with one another, and by discussion, the delegates learned what was needed, and in a large majority of cases they went home and attempted and in many cases succeeded in interesting their states in the subject. To aid in understanding the situation, the bureau compiled all the state and national laws on the subject of weights and measures, and also made a report on the laws and regulations governing this matter in the more important European countries. The third conference, in 1907, adopted what was termed a "Model State Law" based both upon existing state laws and the laws of other countries. This "Model Law" has since been improved and its provisions have to a large extent been incorporated in recent laws enacted by the states.

While the conferences were an invaluable aid to what had now become a real movement to bring about more uniform and efficient laws, and while much valuable information was obtained from the delegates, as to the conditions in their states, the need of first-hand information on the conditions throughout the country was felt, and an appropriation of $10,000 was asked for and granted by Congress for the year 1908–09, for the purpose of making such an investigation. The same amount was granted for the succeeding year, and every state in the Union was visited.

The first investigations were made in cities near Washington, in order that if any unexpected difficulties should arise communication with the Bureau would be easy. The inspectors were provided with portable outfits, and made such inspections of the weighing and measuring apparatus as were ordinarily made by the local sealer. That is, they would go into a store, examine the scales, weights and measures, and weigh such packages as were found ready for delivery. At first both inspectors worked together in order to standardize their methods as far as possible; but later they traveled independently of one another and met only at intervals of two or three months when their paths happened to cross or when they were ordered back to Washington for consultation. In order to get at the actual existing conditions, we attempted to complete the investigation in any city before calling on the local sealer, where there were such, and in a few instances this was misunderstood and resented. It was the desire of the bureau to assist and cooperate with the local sealers, but it was obvious that the results found might have been greatly affected by the knowledge upon their part that a government inspector was in town. In most instances, however, the local sealers were glad to see the inspectors and assisted them in every way to get the information they were after. It ought to be said that the cordiality with which they were received was directly proportional to the efficiency of the sealers. To such as were efficient, our reports and cooperations were of the greatest aid in getting additional help and facilities, as well as in having their ordinances improved. And in other cases where there was no inspection or where the service was poor, the reports were the means of bringing the situation to the attention of the officials and of the people, which frequently resulted in the establishing of inspection departments or of improving the one already existing. In consequence of this activity the Bureau of Standards received many requests from city officials and others for assistance in bettering conditions. To assist in meeting these demands the bureau prepared a model city ordinance on weights and measures, and gave advice regarding suitable standards and apparatus, and on other important matters.

Altogether, 184 cities or towns were inspected, ranging in size from New York with four or five millions of inhabitants, to Carson City, Nevada, with about 2,200; and it will perhaps be interesting at this point to give some of the results found, which includes to July 12, 1912, when the work was practically completed.

Summary of Apparatus Examined by Inspectors of Weights and Measures, Bureau of Standards

| | | Percentage |
|---|---|---|
| Total number of scales tested | 10,034 | |
| Correct | 5,535 | 55.2 |
| Incorrect | 4,499 | 44.8 |
| Total number of weights tested | 12,211 | (partly estimated) |
| Correct | 9,792 | 80 |
| Incorrect | 2,419 | 20 |
| Total number of dry measures tested | 5,656 | |
| Correct | 2,935 | 51.89 |
| Incorrect | 2,721 | 48.11 |
| Total number of liquid measures tested | 2,407 | |
| Correct | 1,761 | 73.16 |
| Incorrect | 646 | 26.84 |
| Total number of stores visited | 3,220 | |
| Total apparatus of all kinds inspected | 30,500 | |

This shows that nearly 45 per cent. of all the scales tested were three or more per cent. in error, and when the rapidity with which a tradesman sells his wares is considered, even three per cent. is an important consideration; and when it reaches twelve, as it did in a number of cases, the loss to the purchaser is a serious one. It is not only the purchaser who suffers from the use of such apparatus, but the honest dealer is placed at a great disadvantage by reason of the fact that the possessor of such a scale can apparently undersell him and yet actually charge more for his goods. To show how apparently small errors run into money, we shall take the case of print butter. It will suffice for our purpose if we select states from different sections of the country, and base our conclusions upon what is found there. Let us take the states of Alabama, California, Massachusetts, Montana, Nebraska, New York, Texas, Utah, and the District of Columbia. The number of prints of butter of various sizes weighed in these states was 3,972, aggregating some 4,434 pounds of the commodity. The average shortage of all this butter was found slightly to exceed $\frac{1}{2}$ oz. per pound, or 3.25 per cent. According to the Bureau of Labor (now the Bureau of Labor Statistics), the normal male adult in all parts of the United States consumes about 30 pounds of butter per year. Tables issued by the same bureau show the percentage of this amount consumed by female adults, children of various ages, etc. By combining these data with the information issued by the Census Bureau as to the number of male and female adults, children, etc., we reach the conclusion that the amount consumed by the total population would be equal to the amount consumed by a number of adults represented by 80 per cent. of the population. The population of the country according to the census of 1910 is approximately 92,000,000, 80 per cent. of which is 73,600,000. Multiply this figure by 30, the number of pounds of butter consumed by one adult, and we find that the total consumption in the United States amounts to about 2,200,000,000 pounds per year. Much of this butter is sold in bulk, but there is no section of the country where print butter is not extensively sold. In the western states it is retailed in no other way. In the eastern states from 25 per cent. to 50 per cent. of it is handled in this form. It is a very conservative estimate to assume that 35 per cent. of the butter consumed is put up and delivered in this form. It may be said, then, that some 770,000,000 pounds of butter are sold yearly in print form, and since the average shortage, as mentioned above, is about 3.25 per cent., the yearly loss on butter in this form is, therefore, 25,000,000 pounds. Assuming that the average price of butter throughout the country is 33 cents per pound, the annual loss to the consumer is more than $8,250,000.

That some of the shortages found in butter are not accidental, but are the result of deliberate fraud, is proved by a comparison of the weight of the same brands of butter in Denver and Cripple Creek, Colorado. The city of Denver has an ordinance requiring that all prints of butter sold in the city must be labeled with the correct net weight of the contents, and this ordinance is being enforced by a sealer of weights and measures. The city of Cripple Creek has no ordinance and no inspector of weights and measures. Five brands of butter were found on sale in both cities, and all of them were labeled with the weight of the contents, "One Pound," in Denver, while two out of the five brands omitted the statement of weight in Cripple Creek, although the butter was still sold as pounds. The average weight of all the prints of the five brands in Denver was 15.72 oz., a shortage of 1.75 per cent., while the average weight of all the prints of these same five brands in Cripple Creek was only 15.02 ozs., a shortage of 6.12 per cent.

The same kind of losses could be shown to result from the use of false capacity measures, although it is not so easy to prove the figures, on account of the comparative roughness with which such measures are used. Such losses as these are likely to result from the use of relatively correct apparatus such as would be found in first-class stores. Aside from these and by far the larger individual losses are those resulting from the use of false weights and measures and intentional cheating either with false or comparatively correct apparatus. False apparatus is generally very crude in construction and may easily be detected upon examination, although in some cases test with standards are necessary. The users of such apparatus depend to escape detection upon the unsuspecting attitude of the purchaser and their own dexterity in handling the apparatus. Methods of cheating and false apparatus represent wide varieties. Among the different types of false measures might be mentioned those having movable or false bottoms; measures having a portion of the height cut away from either the top or bottom; measures with staves removed and the hoops and bottom adjusted accordingly; "bottomless" measures which have relatively small diameters and high sides, and which, although they contain the proper number of cubic inches, give incorrect quantities on account of not permitting of a proper heap; measures with false interiors, such as have been found in milk cans and measures for selling gasoline; and liquid measures used for dry commodities. This last practise is found in use to some extent in practically all parts of the country and results in a shortage of about 14 per cent. It is one of those practises which has come into use largely through "trade custom." The use of correct scales of high quality is not in itself a guarantee that correct amounts will be given, for it is possible for the user of such apparatus to manipulate it to his own advantage; but it is usually with the poorer apparatus and small dealers where intentional fraud is found. A type of scale which was formerly common among certain classes of dealers is the straight-face hand scale, with the graduated face made movable so that the dealer might lower or raise it so as to make the pointer indicate a lesser or greater amount than actually was the case, according as he was buying or selling. Even-arm balances of cheap construction may be made to vary considerably by placing the weights and commodity in certain positions on the pans, which is done in an apparently unintentional manner by the dealer and which would not be noticed by the customer unless he were familiar with the action of such scales. Counter-beam scales with a movable scoop and counterpoise may very easily be used fraudulently by omitting the counterpoise when the scoop is in place. These are a few of many ways in which apparatus designed to give correct results may be changed or used to give incorrect amounts.

The results of the investigations, which were furnished to the state and local officials, were an important factor in convincing the legislatures of the states that the state laws and the facilities provided for carrying them out were in most cases entirely inadequate to protect the public not only from the use of fraudulent apparatus, but also the fraudulent use of correct apparatus. The wide publicity given in some of the magazines and newspapers to the work of a few of the more progressive states also contributed to concentrate the attention of the state legislators on the necessity for a more efficient supervision of commercial weighing and measuring. Let the reasons be what they may, the past two or three years have seen the most astonishing activity in the legislatures of the states.

The original idea of the Bureau of Standards was to have the states adopt uniform laws and then to enforce them. It did not take it long, however, to learn that it would be an impossibility to get the same law passed by all the states. It was also evident that even with the same law, the enforcement by the different states would be anything but uniform. The idea now, therefore, is to secure uniformity as far as possible with such changes as are necessary to meet local conditions, and enough federal legislation to give the government the authority to regulate the matter so far as interstate commerce is concerned. It is obvious that an individual or corporation doing business in all the states should not be compelled to conform to conflicting state laws.

During the past two of three years the following legislation was enacted in the states:

Alabama passed legislation amending the law in relation to the sale of certain specified feeding stuffs. It is now required that when put up in original packages they may only be packed in certain specified sizes and the net weight must be plainly stamped on the outside of the containers. This is a good law and a step in the right direction, but it is very greatly restricted in its operation on account of the small number of commodities specified.

Arizona passed a general weights and measures law during the first session of the legislature after being admitted to the Union, which shows the importance of this subject in the minds of the legislators of that state. The law is based directly on the model law recommended by the National Conference on Weights and Measures, many of the sections having been enacted without material change. On the whole the law is a good one, and Arizona is to be commended upon its general effectiveness and its early passage. The system adopted requires the appointment of city sealers in all cities of more than 5,000 population who are placed under the supervision of the state inspector. In cities of less than 5,000 and more than 1,000 population the work of inspection is to be done directly by the state inspector. Communities of less than 1,000 people do not seem to have been provided for in this law. In addition to the sections relating to the inspection of apparatus there are provisions requiring most package goods to be marked with the net weight or quantity of the contents, and others regulating the sale of wood, ice, hay, fresh meats, butter, etc. Later the scope of the law was broadened by requiring that the testing of water, gas and electric meters should be in charge of the city sealers and the state inspector of weights and measures. The most unsatisfactory feature of the legislation is that requiring fees to be collected from those for whom inspections are made; but fortunately the state inspector and city sealers are to be paid by salary. The ale gallon of 282 cubic inches adopted for the sale of beer and ale should not have been established, since this measure is not recognized by the federal government.

Arkansas passed somewhat similar legislation in 1911 and later enacted a law directing and requiring that the county clerks comply with the provisions of a law passed in 1894, requiring that the county clerks procure a complete set of standards and seal all weights and measures that may be presented to them for that purpose which correspond with the county standard. The law also provides that the township constable and the town or city marshal shall make annual inspections of the weights and measures in their respective jurisdictions, and stipulates a penalty of $1 a day for failure of the user of weights and measures to have his apparatus tested and sealed before the first day of September of each year. The enactment of this law shows an awakening interest on the part of Arkansas in a subject which has laid dormant in that state for many years; and while the system adopted will not attain the highest results, it is hoped that it may be only a forerunner to the establishment of a state-wide inspection of weights and measures along the most approved lines.

California has been exceedingly active in its endeavor to protect the people of the state, although it has never been represented at the National Conferences on Weights and Measures. During the visit of our inspector a proposal was made to one of the state senators that he undertake to draft a bill covering the matter. It was at once seen that this would be a difficult task on account of a provision of the constitution which forbade the appointment of a state sealer of weights and measures and made it impossible to compel the cities and counties to appoint such officers. A bill was finally drafted which was probably the best that could be passed under the constitution. Also a constitutional amendment was introduced designed to remove this disability from the state. Both the bill and the constitutional amendment were successful, and a number of counties and cities appointed sealers under this law. The bills were passed almost unanimously, the reports issued by the Bureau of Standards upon conditions as they were found to exist aiding greatly in the passage. A special election was held in October, 1911, and the weights and measures amendement and a number of other constitutional amendments were voted upon by the people. This provision was passed by an overwhelming majority. At a recent special session of the legislature a new bill was introduced containing all the provisions recommended by the conference. This bill passed the senate almost unanimously and appeared certain to become a law, but opposition developed in the assembly taking the form of amendments designed to decrease the effectiveness of the law. At a conference the senate refused to concur in the amendments and on account of the lack of time the bill failed of passage. Ten thousand copies of the reports of the Bureau of Standards, showing the necessity of inspection service and the extremely bad conditions existing were printed by the senate and with this assistance the bill became a law at the next session of the legislature.

There was also passed a net container law applicable "to food-stuffs and stuffs intended to be used or prepared for use as food for human beings" and "to any commodity intended to be eaten or drunk by human beings"; but it does not apply to commodities intended to be used solely for medicinal purposes or to a quantity of a commodity that is sold for less than eleven cents at retail. The act contains several provisions concerning the manner of marking the net weight, measure or numerical count, and fixes a minimum penalty for violation of $25 and a maximum of $500.

Colorado passed four laws on the subject of weights and measures at the 1913 session of its legislature, prior to which this subject had been a dead letter in Colorado for nearly a score of years. One of these laws gives the Public Utilities Commission power to examine and test all water, gas and electric meters; another requires persons or corporations engaged in business of mining and selling by weight to keep constantly on hand the necessary apparatus to correctly weigh their product, and provides for the annual inspection of such apparatus and makes further provision for the proper weighing of coal mined in the state; a third law requires that oleomargarine be put up in print form of one half, one, two, three, and five pound prints and in no other larger or small subdivisions, and sets forth other restrictions regarding the marking of the weight; and the fourth law provides against the false reading or manipulation of the Babcock test for milk and cream.

Connecticut passed a most excellent law including nearly all the provisions recommended by the conference for general legislation, and also requiring the net contents to be stamped on the outside of all original containers of food.

Delaware passed two laws; one requiring that a standard ton of coal shall consist of 2,240 pounds and providing a heavy penalty for violation, and the other law specifies standard cups, hampers, baskets, barrels, etc., to be used in shipping berries, fruit and produce. The latter law is not mandatory, but permits the use of other size containers when properly marked with the amount that they contain.

Florida failed to pass any general legislation requiring inspection service, but this state distinguished itself by amending its pure food law so as to require that the net contents of all original packages should be "conspicuously, legibly, and correctly stated" in terms of weight or measure, on the outside of each package.

Idaho passed a law at the last session of its legislature which establishes the customary standards and materially enlarges the powers and duties of the state sealer of weights and measures who, by a former act, is the dairy, food and sanitary inspector of the state. The present act makes it mandatory for the state sealer to test and seal or condemn all apparatus used in the state. Cities and municipalities are given the power to appoint sealers and pass ordinanecs not in conflict with the laws of the state. A large number of dry commodities for which legal weights are specified, must be sold only by weight; berries and small fruits, when sold in boxes, must be sold only in those containing a standard dry quart or dry pint unless information that the boxes hold less than this amount is given to the purchaser and a statement of the net contents is labeled on the box; milk and cream must be sold in standard size bottles; pails of lard must be labeled with the net weight; prints of butter containing less than 16 ounces must be labeled with the weight; and bread must be sold by weight.

Illinois passed a law which is lacking in scope and does not provide any officials whose sole duty it is to enforce the law, but its execution depends upon the Secretary of State who is *ex-officio* sealer of weights and measures, and the county clerks of the several counties who are county sealers of weights and measures; the former being charged with the care and custody of the state standards and the trying and proving of the county and municipal standards, and the latter with the duty of trying and proving all weights and measures, scales and beams within their respective counties when requested so to do. Fees are provided for the paymentof services rendered in testing and sealing; and this is a very undesirable feature of the law, as such a system is not conducive to the attainment of the best results, and is generally believed by weights and measures officials to be wrong in principle and unsatisfactory in practise. The weights per bushel of a large number of commodities are fixed. Section 17 of the law is worthy of commendable notice, since it gives authority to weights and measures officials to seize and hold for use as evidence in any suit any short measure or faulty or incorrect weighing or measuring instrument or any commodity or article of merchandise which is of less weight or measure than represented, and the sealer is not held liable to the owner of the property seized for damages caused by such seizure where reasonable grounds existed for the action of the official. While the law is incomplete in its provisions, in fact, is entirely lacking in many which are indispensable to the attainment of the best results in weights and measures work, inadequate in the machinery provided for its enforcement, and not in keeping in progressiveness with the position of Illinois among the sister states of the Union, it is to be hoped that the start thus made will expand, and that a competent law and adequate force will soon be had.

Indiana introduced a bill to amend the law passed in 1911, and, after much debate and some amendments, it was finally enacted into law. One of the principal objects of the bill was to make it mandatory on the counties to appoint sealers of weights and measures, the original law merely being permissive in its terms. The bill, as originally introduced, required all counties with over 20,000 population and all cities of the first and second classes to appoint such officials. As finally passed, however, the only counties required to appoint sealers are those of 40,000 or more population which do not contain a city of the first, second, third, or fourth classes already having such an official. As a result of thus increasing the population requirement the number of new sealers required to be appointed was very materially reduced. There are other features of the law which are both important and excellent ones; for instance, that putting the city sealers under the municipal civil service regulations, and that requiring all commodities to be sold by weight, measure or numerical count rather than in the indefinite manner so common heretofore.

Iowa passed a general law which contains some of the provisions recommended by the National Conference on Weights and Measures. The state dairy and food commissioner is charged with the duty of carrying into effect the provisions of the law and is required to appoint a chief inspector of weights and measures with the approval of the executive counsel, and the appointment of other inspectors is provided for. The dairy and food commissioner is also required to appoint an employee of the dairy and food commission to be state sealer of weights and measures, who is charged with the care and custody of the state standards, general supervision over the weights and measures and weighing and measuring devices of the state, and the testing and calibrating all apparatus used as standards in the state. The law fixes the weight per bushel of a large number of commodities and specifies that they shall be sold by weight unless there is a special agreement in writing to the contrary; but in the case of berries in packages of one peck or less they may be sold by the quart, pint or half pint dry measure, and all berry boxes must be of the interior capacity of one quart, one pint or half pint, dry measure. Confiscation of berry boxes not conforming to these standards is provided for. All dry commodities, weighing ten ounces or more, with few exceptions must be bought and sold by standard weight or numerical count, lineal measure, or surface measure, except where parties otherwise agree in writing.

Kansas was more or less active in passing weights and measures legislation, but its progress was very largely in a backward direction, if you will pardon the anomaly. The laws we criticize are two in number: the first specifies that flour and cornmeal when sold in sacks in amounts less than one barrel shall be sold by gross weight. The second law is no less inimical to sound legislation and good practise. This law establishes the liquid measure for the sale of berries and small fruits in baskets in place of the dry measure which has heretofore been the universal standard for these commodities. A provision of the general law which has been found to be very obnoxious is the provision requiring the collection of fees for services rendered by the sealers of weights and measures. So firmly, however, is the fee system engrafted on the state that cities passing ordinances are not allowed to abolish them, but must always make the collections demanded. We are informed by the state officials that this requirement is the greatest stumbling block in the path of establishing a really efficient inspection service and eliminating faulty weights and measures from the commerce of the state.

Three other laws were passed at the last session of the legislature: one requires railroads to provide scales for weighing live stock at all stations where as many as 50 carloads of live stock were received for shipment during each of the preceding two years; another requires the net weight to be marked on commercial feeding stuffs; and a third law requires similar marking for live stock remedies.

The law passed in Louisiana provides for the inspection of weights and measures in the city of New Orleans only. The city is divided into two inspection districts for which two inspectors are to be appointed by the governor with the advice and consent of the senate, for a term of four years. Fees are to be collected for testing and sealing apparatus, but the inspectors are placed on a salary basis. Trade weights and measures are to be inspected and sealed annually, and it is made unlawful to use such apparatus without being inspected and sealed. Itinerant peddlers and hawkers using weighing and measuring instruments are required to bring them to the office of the inspector to be adjusted and sealed before using them, and to have the same adjusted and sealed annually. The law includes several provisions contained in the model law recommended by the National Conference on Weights and Measures. Another act was passed requiring ice wagons to be equipped with weighing devices, making it unlawful to charge and collect for a greater amount of ice than actually delivered to the consumer, under penalty of fine or imprisonment.

Maine passed one general and two special laws on the subject at the last session of the legislature. The general law is in the nature of amendments to the former statutes of the state, passed principally at the 1911 session, and adds a great deal to the strength of these laws. The major portion of the changes are based on sections of the model law recommended by the National Conference on Weights and Measures. A berry box section was included which requires all boxes for berries holding one quart or less to be of the capacities of one quart, one pint or one half pint, standard dry measure. The section specifying the weights per bushel of commodities has been extensively revised. An act relative to sealing milk bottles and jars requires these to be of standard capacities with the usual tolerances, and contains most of the other provisions of the milk bottle section of the model law.

Maryland completely revised its statutes on the subject of weights and measures and the new law provides for a complete system of county and city inspection, under the salary system. The most serious defect in this law is the omission to provide any state supervision whatever. It has been found in the past that without some state officer to assist the local sealers, the enforcement of any law is lax and unsatisfactory and it remains to be seen whether Maryland can succeed where so many states have heretofore been unsuccessful.

Massachusetts made several important additions to the statutes during the past three years. In 1911 two laws were added in relation to the cranberry barrel and other packages and to the weight of a barrel of potatoes. In 1912 the list of legal weights per bushel for fruits and vegetables was amended and amplified and it was provided that all fruits and vegetables for which a legal weight was established should be sold only by numerical count or by weight, thus eliminating the use of the dry measure for a very large number of important commodities. At the last session of the legislature a determined effort was made to nullify this law and to reintroduce the old method of selling by measure, a bill being introduced to this effect. This passed the lower house but was defeated in the senate; so the ground gained has not been lost. The second important amendment was the passage of a bill making it unlawful to sell any commodity by any other weight than the net weight of the commodity. It is believed that the sale of commodities by gross weight can be prevented, regardless of any statement to the contrary, under the terms of this law. The abuse of charging retailers and consumers for wooden cores, backsticks, heavy burlap and paper wrappings, cord, etc., at the price of the commodity itself upon the strength of a statement upon the invoice or delivery ticket that the delivery is made "gross weight," may thus be eliminated in this state by a competent enforcement of this law. Other bills were also enacted requiring the measuring by sworn city or town officials of all leather sold by measure; and the testing and sealing or condemning of all machines used in the measuring of leather. On account of the very large shoe manufacturing industries in this state this subject is of very great importance here.

Michigan enacted legislation at the last session which was based directly on the model law. Some of the sections were adopted practically intact while others were amended in important particulars, these amendments in nearly every case, however, tending to weaken the original law. The state dairy and food commissioner is, by virtue of his office, the state superintendent of weights and measures for the state. His deputy is likewise deputy state superintendent of weights and measures and all inspectors in the dairy and food department are state inspectors of weights and measures as well. The next important amendment apparently prevents the confiscation and destruction of incorrect apparatus. The provision that counties and cities appoint sealers of weights and measures is not mandatory, but they may do so "in their discretion." The penalty section has been weakened by requiring that before conviction it must be proven that short weight or measure has been "knowingly" sold or offered for sale. The difficulty of proving the state of a man's mind, even in flagrant cases of fraud is well known and need not be commented upon here.

Minnesota enacted an excellent law in 1911 providing for a state commissioner of weights and measures and a state inspection of the apparatus in commercial use. The most unfortunate provision of this law is that requiring the charging of fees for work done. The enforcement of this law should be of particular interest, since this state is among the first to abolish local sealers, putting the matter entirely in charge of state officers. Should its enforcement meet with success it may point out the proper method of inspection for some of the western states where a small number of people are scattered over a very large territory. At the last session of the legislature several valuable additions were made to the law. One section relates to the standardization of boxes used in the sale of berries, allowing containers of the capacities of one quart, one pint, one half pint or multiples of a quart, standard dry measure only; another provides for better equipment for testing railroad track scales; another gives the Warehouse Commission jurisdiction over the track scales used by common carriers and the power to require the installation of the same; it is still further provided that the Warehouse Commission may compel railroads to furnish scales for free public use in stockyards; and finally, there are general amendments to the weights and measures law of the state.

Missouri passed three laws: one authorizes cities of from 30,000 to 75,000 inhabitants to establish standards of weights and measures not inconsistent with the Federal and State standards, to provide for the inspection of all weights and measures and to prescribe the weight and quality of bread sold in the city; another gives the Public Service Commission authority to appoint inspectors of water, gas and electric meters; and a third law requires that the Commission shall appoint weighmasters at such places in the state where grain inspection and weighing may be established in conformity with the provisions of the law.

In 1911 Montana passed a general law which was on the whole a good one and contained a large number of the provisions of the model law recommended by the National Conference on Weights and Measures, but also included certain other features which were unsatisfactory, among these being the collection of fees for the work done and the appointment of county clerks as sealers of weights and measures. At the next session of the legislature this law was repealed and reenacted with important changes; and it appears that the statute has been greatly strengthened and improved as a result. The county clerks are no longer designated sealers of weights and measures for their respective counties, but instead the state sealer is authorized to create weights and measures districts and appoint inspectors therein. The state sealer is given specific jurisdiction over the track scales of the state; a net-contents-of-container section was added to the law, as well as a general net weight provision; and the penalty section has been greatly strengthened. Another very important and excellent change is the abolition of the fees formerly required to be collected by the state sealer of weights and measures and his deputies for the work performed by them.

Nebraska passed, at the last session of its legislature, a weights and measures statute which is general in its terms but which fails to provide a mandatory inspection of all weights and measures in commercial use although it appears that it is possible to obtain this object under the terms of the law. The deputy food, drug and dairy commissioner is the deputy state sealer and to him and his assistants is entrusted the state supervision provided for under the act. These officials may test weights and measures but it does not seem that they are required to do so. Fees are to be collected for the work done by them, these fees to be used in the proper enforcement of the law. No other money is appropriated for this purpose. In the counties the county clerks are designated sealers of weights and measures. They are required to test apparatus only upon request although they may do testing work at other times if they so desire. Cities or municipalities are empowered to establish inspection services but are not required to do so. On the whole it does not appear that the act is a very satisfactory one, although it may be considered as a forward step in legislation in this state.

Up until 1911 Nevada was distinguished by the fact that it was the only state having no laws whatever on the subject of weights and measures. In that year a very satisfactory law providing for a state inspection of apparatus under the supervision of the director of the Nevada Agricultural Experiment Station was passed, and very wide powers were given to the state officials. No local inspectors were provided for, and rightly we believe, on account of the small population of the state and its large territory. To make up for its neglect in the past, perhaps, the legislation included in its provisions that original packages must be labeled "in plain intelligible English words and figures with a correct statement of the net weight, measure or numerical count of its contents." By a subsequent amendment to section 23 of this act, the commissioner appointed by the board of control of the Nevada Agricultural Experiment Station was made sealer of weights and measures and charged with the duties which formerly developed upon the director of the said station.

New Hampshire amended the penalty clause of the law in force, making it much broader in its scope. They also increased the powers of the sealers to some extent, revised the schedule of legal weights per bushel, and passed an excellent berry-box section requiring that all such boxes used in the sale of specified berries shall be only of the sizes of one quart, one pint or half pint, United States standard dry measure.

New Jersey passed a very comprehensive law in 1911 establishing a state department of weights and measures, consisting of a superintendent and three deputy superintendents, and providing for the testing and sealing of apparatus by county and municipal superintendents. This law is directly based upon legislation recommended by the conference, but it was quite generally amended before its passage, to meet local conditions in the state. At the 1913 session of the legislature several amendments were passed, designed to strengthen the former law by making it possible to eliminate dealing which, while resulting in false representations and fraud, could not be attacked directly under the former provisions. Perhaps the most important of these changes is that standardizing the size of baskets used in the sale of dry commodities. Formerly all kinds of odd sizes were used and when these were sold in competition with each other it was very difficult for the purchaser to buy efficiently, since the amount to be obtained could not easily be ascertained. It is now made unlawful to manufacture, use, or offer or expose for sale any other baskets than the standard sizes mentioned in the act. Enforcement of this law should result in the elimination of misrepresentations of quantity and assure the purchaser of the quantity received. Another law gives the weights and measures officials police powers in connection with their work, and this will assist them very materially in many cases in bringing offenders of the law to justice. The penalty section has been strengthened and the procedure to be followed in the arrest and trial of offenders has been defined with great particularity. The magistrate shall hear and determine the guilt or innocence of persons summoned, in a summary way, and upon conviction a penalty may be enforced by execution against their goods and bodies without any special order of the court.

New Mexico passed a general law on the subject of weights and measures, designed to establish a state-wide inspection of the weights and measures in commercial use. The law is an inclusive one and evidently endeavors to cover the entire subject. While it has many excellent provisions the machinery provided for enforcement is very poor and it also contains many unsatisfactory and indefensible provisions. The legislation is not based on the model law of the National Conference, but does seem to have copied provisions from a number of other states. Some of the provisions which are considered poor ones will be mentioned briefly. The only state weights and measures official provided for is the secretary of state, ex-officio, and his only duties appear to be the providing and testing of county standards. The sheriffs of the counties are designated county weighmasters, these officials being allowed to appoint deputies to enforce the weights and measures laws. Fees are to be collected for all work done and these fees are to be kept by the officials for their own use, no other compensation for the performance of the duties specified being provided. The only state standards required to be procured and kept are weights of specified sizes, although in a later section "all weights and measures accepted and used by the government of the United States at the present time, except herein provided" are standardized. The only commercial apparatus required to be tested and sealed are scales; weights, measures of capacity and length and measuring apparatus of all kinds being entirely neglected in this connection. All berries sold in boxes must be sold in boxes containing a standard liquid quart or liquid pint, and boxes of all other sizes must be labeled with their net contents. New Mexico has evidently followed the lead of Kansas in this matter, although such a provision is one of the most regrettable ones which could be included in a state law.

New York continued the good work which it commenced several years ago, and added to its excellent code of laws a very strong coal law, and a law making the possession or use of any false apparatus presumptive evidence of the knowledge of the user of its falsity. A law was recently passed requiring that all meat, meat products and butter shall be sold by weight, and that other commodities shall be sold by weight, standard measure or by numerical count, and that this amount must be marked on a label or tag attached thereto. The law further fixed the sizes of containers for vegetables, produce and fruit and provided that when these were sold in other than standard sizes the amount contained in these packages should be marked or branded conspicuously in terms of standard dry measure on the outside of the package. And it is also specified that when commodities are sold in containers of other sizes than those fixed by law the net quantity of the contents of each container, or a statement that the specified weight includes the container, the weight of which shall be plainly and conspicuously marked, branded or otherwise indicated on the outside or top thereof or a tag attached thereto, in terms of weight, measure or numerical count. During the 1913 session another law was passed standardizing the dimensions of four- eight- and twenty-pound baskets for use in the sale of grapes and provides that grape baskets of all other sizes must bear a statement of the net quantity of their contents in terms of weight, measure or numerical count. The section of the present code of laws relating to the marking of bales of hay and straw was strengthened by an amendment.

North Dakota took an important forward step by requiring that lard put up in pails or other containers should not only be marked with the net weight of the contents, but should also be put up in one, three or five-pound net-weight containers or some whole multiple of these numbers, and not any fractions thereof. This legislation was taken into the courts and we are under the impression that it has recently been declared constitutional. A law requiring bread to be put up in standard size loaves or labeled with their weight was also put upon the statute books. A section of the code conferring certain powers upon cities was amended so as to permit the establishment of city scales and certain other powers, which now appear to be exercised by the state, were withdrawn from the cities.

Ohio, in 1910, placed the inspection of weights and measures under the direction of the state dairy and food commissioner, and the law gives him the authority to use the services of any persons employed under his department in the enforcement of the laws relating to weights and measures. The county auditors were made county sealers of weights and measures and are required to compare all weights and measures brought to them for the purpose with copies of standards in his possession, to see that the state laws relating to weights and measures are strictly enforced, and to assist generally in the prosecution of all violations of such laws. Mayors of cities and villages may appoint sealers of weights and measures. Several other laws relating to weights and measures were passed or amended at the 1910 session of the legislature. In 1911 several changes were made in the laws. The most important was the section making it necessary to sell a large number of dry commodities specified by avoirdupois weight or numerical count, unless all parties concerned agreed upon some other method of sale. This legislation is most important since it is the first statute passed by any distinctively eastern state attempting to eliminate the always-faulty dry measure from commercial use.

At the 1913 session Ohio strengthened the law requiring fruits and vegetables to be sold exclusively by numerical count or weight and has thereby made it possible to enforce its provisions competently. In the former law these commodities might be sold only as mentioned above, "unless by the agreement of all contracting parties." This phrase made it extremely difficult to obtain convictions even in cases of willful violation of the intent of the law. The amendment referred to requires these special agreements to be in writing and hereafter it would seem to be an easy matter to bring all offenders against the spirit of the law to justice. The section requiring berries and other small fruits to be sold by a bushel or fractional part thereof has been amended to require the subdivision of the bushel to be an aliquot part thereof. Dry measures have been standardized as to the diameter and depth to be required. The state sealer has been given the power "to make, publish and enforce such rules and regulations as may be necessary to the prompt and effective enforcement of the weights and measures laws of this state." A special section requiring the testing of the computing part of computing scales has been added; and finally, the word "knowingly" has been stricken out of the penalty section. All of these latter amendments seem to be excellent ones and do much to strengthen the weights and measures law of the state.

Oklahoma during the years 1910–1911 revised the list of legal weights per bushel, required certain commercial feeding stuffs packed in sacks to bear a statement of the net weight of the contents, made some changes in the coal mining law, and standardized the weight of flour and meal put up in barrels and sacks and required the weight to be branded on the same. As in the case of Kansas, flour in cloth sacks may be branded with the gross instead of the net weight.

Oregon passed one general and four special laws relating to weights and measures at the 1913 session of its legislature. The general law establishes a state department of weights and measures under which the state treasurer (who it appears from the context is subsequently referred to as the state sealer) is required to appoint a deputy state sealer and has authority to appoint such assistant and clerical aid as may be necessary to place in practical operation the provisions of the act. He is further authorized to procure such standards and other equipment as may be necessary for the proper execution of the duties under the law and to procure and use only such standards as have been passed upon as correct by the National Bureau of Standards and to have the state standards tested by that bureau once in ten years. The county courts of the several counties are required to appoint competent sealers for such term and at such compensation as they may decide; but such sealers may be removed from office by the deputy state sealer for incompetency, or neglect of duty. The county sealer is required to visit at least once in each year every place of business where weights and measures are kept for the purposes of trade. The law places no restriction upon the rights of cities to enforce ordinances providing for the sealing of weights and measures or regulating the sale of commodities, provided such ordinances are not in conflict with the standard adopted by the state. It is made unlawful in selling any commodity by weight or measure to include the weight or measure of anything other than the weight or measure of the commodity itself. The law, while lacking in some respects, contains a number of excellent provisions and may in general be said to be a good one. The four special laws referred to above, provide as follows: One establishes a weight of 100 pounds, inclusive of the weight of the sack, as the standard weight of a sack of potatoes, unless otherwise specified by contract; another stipulates that in selling farm or range products where no special agreement is made to the contrary, no deduction shall be made for the weight of the sack containing the products; another refers to the sale of butter, and requires among other things that this product when offered for sale in rolls, prints or squares, shall be plainly marked "Sixteen ounces, full weight," or "Thirty-two ounces, full weight," and shall contain the number of ounces so marked; and the fourth law amends a former act and places all track scales used by railroad companies under the jurisdiction of the Railroad Commission, the Commission being required to test and inspect such scales from time to time, the cost of which is chargeable to the owner of the scale.

Pennsylvania passed a law in 1911 establishing a state bureau of standards, under control of an officer to be known as "Chief of the Bureau of Standards," with very limited powers. The counties and cities were authorized, but not required, to appoint inspectors of weights and measures and the powers and duties of these officers were specified. This law did not require any compulsory inspection service, either state or local, and was inadequate on this account. At the 1913 session the above-mentioned law was amended in several particulars which has greatly strengthened it, and it now becomes possible to secure far greater results than formerly. The permissive character of the act relating to appointment of weights and measures officials is now made mandatory, and requires that mayors of cities of the second and third classes and the board of county commissioners of the several counties shall appoint one or more competent persons as inspectors of weights and measures. In cities of the first class, the inspectors are to be appointed by the board of county commissioners of the county in which such city is located rather than by the mayor of the city. It is provided in the law as amended that the county and city inspectors shall hold office during good behavior, and shall not be removed, discharged, or reduced in pay or position, except for inefficiency, incapacity, conduct unbecoming employees, or other just cause, and until said officials shall have been furnished with a written statement of the charges against them, and shall have been given reasonable time to make written answer thereto. This provision practically means civil service, and puts the inspectors beyond removal for political reasons, and permits them to become proficient in their work and to remain in office, thus rendering to the community better and more efficient service than would be had with constant change of inspectors at intervals of one or two years. Another act was passed relating to the sale of commodities, which specifies the manner of sale of certain kinds of products, and attempts to prevent misrepresentations and the use of fraudulent apparatus. This act also fixes the number of pounds per bushel for a large number of commodities in section 6, and in the following section, requires the net weight, measure, or numerical count to be marked on packages; but it is not mentioned in this section what commodities or classes of products in package form are required to be so marked. It might be inferred from the context that reference was made to the commodities mentioned in the preceding section, but such a construction does not appear to be a reasonable one.

South Carolina passed legislation fixing a standard weight per bushel for a very large number of dry commodities and also providing for standard barrels for various purposes. It is made unlawful to sell any of the products mentioned "except in strict accordance with the standard weights and measures'" so provided, and means of enforcement and penalties for violations are included in the act.

South Dakota has not enacted any general laws, but in 1911 amended the food and drugs act to require the true net weight to be branded on all food sold in original packages "in clear and distinct English words in black type on a white background, said type to be in size uniform with that used to name the brand or producer." At the 1913 session of the legislature a law was passed establishing the bushel, and subdivisions, as the standard for all dry commodities, and fixing the weights per bushel of a large number of products. It is also made unlawful in the sale of grain to take a greater amount as dockage for dirt, foul seed or other mixture than is actually present.

Tennessee passed a general law on weights and measures, making the state pure food and drug inspector the state superintendent of weights and measures, and designating his assistant and deputy inspectors as assistant sealers, with like powers and authority as the county and city sealers. The president of the University of Tennessee is made the state sealer of weights and measures, and among other duties, is charged in conjunction with the state superintendent, with the care and custody of the standards and the inspection and testing of the standards of the several cities and counties, and the testing and calibrating, when presented for the purpose, of apparatus used as standards by any citizen, firm, corporation or educational institution of the state. The state superintendent or his deputies are required to inspect the work of the county and city sealers once in two years, and for this purpose have the same powers and authority as the county and city sealers. The law relating to the appointment of county and city sealers is only permissive in its terms, and presents one of the weakest features of the act. The powers granted to, and the duties required of, the county sealers (and likewise of the city sealers and assistant and deputy inspectors of the pure food and drug department) follow very closely those contained in the model law recommended by the National Conference on Weights and Measures, and are potentialities of far-reaching possibilities and capable of accomplishing a vast amount of good in the state if the county and city authorities avail themselves of the opportunities afforded by the law. Otherwise, it does not appear that much can be accomplished, unless the state superintendent is able to have a considerable portion of the time of his assistant and deputy inspectors devoted to the inspection of weights and measures, the appropriation allowed for use in the inspection of weights and measures being only one thousand dollars. The state superintendent, in conjunction with the state sealer, is required to make rules and regulations for the enforcement of the act and for the guidance of all city and county sealers.

Texas passed an act requiring ginners of cotton to mark the weight of the bagging and ties in which the cotton is wrapped upon each bale of cotton ginned by them, in figures at least four inches in height. It was required that the net weight of the contents be stamped upon bags, barrels and packages of fertilizers.

Utah in 1911 passed a law general in its terms but very incomplete in its provisions, making the state food and dairy commissioner *ex-officio* state sealer of weights and measures and giving him the power and making it his duty to try and prove all apparatus in use in the state, except in cities having a city sealer. No compulsory local supervision is provided for. Three other laws were passed at the 1913 session of the legislature, the most important one being a net weight law with reference to food in package form, which follows very closely the wording of the amendment to the national law on this subject. The other two laws have reference to the collection of freight charges on cars of coal and the weighing of coal in carload lots; the object of the laws is to ascertain the net weight of the coal, it being provided among other things that the cars shall be weighed before and after being loaded with coal.

Vermont enacted a general law in 1910 providing for a state supervision of weights and measures and authorizing but not making obligatory local supervision, also. This legislation was very satisfactory as far as it went. Subsequently it was amended and strengthened in several particulars. The state department of weights and measures now has specific jurisdiction over the scales used by common carriers; is empowered to seize, for use as evidence, commodities, packages or other articles offered for sale in a manner contrary to law; and is required to pay particular attention to the weights and measures used in creameries. The intentional misrepresentation by the buyer of the amount of commodity purchased is made a punishable offense; and the section relating to the legal weights per bushel was greatly amplified and strengthened.

In 1911 Washington enacted legislation requiring railroad companies to have track scales, and to furnish, jointly, a test car or other device for the use of the Railroad Commission in testing track scales, the railroad companies being required to move the car free of charge. In 1913 there was enacted legislation providing for a state-wide inspection of the weights and measures in commercial use, this law containing most of the provisions of the model law recommended by the National Conference on Weights and Measures. The state inspectors are put in the department of the secretary of state, this official being made *ex-officio* superintendent of weights and measures. The actual work will be taken care of by a deputy superintendent and one inspector. City sealers are required to be appointed in all cities of the first class, while in the counties the auditors are made sealers, *ex-officio*. As in the case of the state, a deputy sealer is required to be appointed in each county, having the same powers as the auditor in respect to this Act, and upon these officials will fall the duty of seeing to the enforcement of the law. In addition to the sections taken from the model law, the manner of sale of butter, bread, potatoes in sacks, berries in boxes, coal in sacks, milk in bottles, and vinegar, ice, and wood are provided for. In regulating the scale of the above-mentioned articles in packages, standard sizes are specified which do not have to be marked with the net contents, but when any other size than the standard is packed, the net contents in terms of weight or measure must be stated on the outside of the package in plain English words and figures.

Wisconsin enacted an excellent general law on the subject, providing for a state supervision of weights and measures under the direction of the state dairy and food commissioner, who is made *ex-officio* state superintendent of weights and measures, and for a local inspection in charge of city sealers in all cities of five thousand inhabitants or more. This law contains nearly all the provisions endorsed by the National Conference on Weights and Measures.

Several amendments were made to this law in 1913. Among the most important of these is one conferring greater authority upon the state superintendent of weights and measures concerning the appointment and compensation of employees, and another requiring food in package form to be marked with a statement of the net weight, measure or numerical count.

Wyoming has not enacted any general legislation on the subject, but a law relating to food was passed in 1911 requiring that "if in package form, the net quantity of contents be plainly and conspicuously marked, on the outside of the package in terms of weight, measure or numerical count." The law in reference to the measurement of hay in stacks was amended, as was also the law in relation to the weighing of coal in mines. In 1913 a law was passed relating to the inspection and analysis of illuminating oils (including gasoline for the purposes of the act) which provides that the absence of the net weight properly labeled on the packages shall be prima facie evidence that they are misbranded.

Altogether forty-one states passed legislation of some sort directly referring to the subject of weights and measures. The statutes in twenty-four of these were general in their nature and authorized or required state-wide local inspection service under the general supervision of a state department of weights and measures; state-wide inspection service under officers of the state without any local inspection service; or local inspection without any supervision by the state. Twenty-eight states passed legislation requiring the weight or measure to be branded on the outside of some original package goods when sold in the original package or required the package or container to be of certain sizes. Of these sixteen referred to some few specified commodities, while twelve were general in their terms. This record shows the remarkable interest that has developed in the last few years and clearly points out the necessity for federal legislation to take care of interstate transactions.

The above list does not show all the activity by any means. A large number of states introduced legislation of some sort but were unsuccessful in enacting them into laws. In a number of these states the idea was new and the bills did not receive sufficient consideration on that account. In others they failed through lack of time at the end of the legislative session, or for other reasons.

There is another phase of the subject that has not been touched upon that is perhaps more important than the supervision of the weighing and measuring apparatus of the tradesman, because of the fact that the amount involved in any transaction is not stated, and that is the sale of goods in sealed packages without any statement as to the quantity in the package.

Prior to the passage of the Food and Drugs Act, it was customary to mark such packages with some whole number of pounds or ounces. Most readers remember the two-pound packages of cereals, and the three and five-pound cans of lard extensively advertised and sold some years ago. It is possible that the weights marked upon them were originally correct, but it is certain that they were not so in 1906, when the Food and Drugs Act went into operation, because the packers immediately stopped marking such packages, on account of the provision in that act which requires that if any weight or measure be stamped upon any package it must be the correct weight or measure. The influences behind the Food and Drugs Bill attempted to have this section read so that the correct weight or measure of the contents should be stamped upon the outside of the packages, but the packers had enough influence to have it modified. The result was that the packer was at liberty to reduce the size of his package as often as he deemed it advisable, and without the knowledge of the purchaser; and this has been done in numerous instances.

The passage of laws by a number of the states, requiring the marking of the net weight, measure or numerical count upon the outside of articles put up in sealed packages, and the delegation of authority by such laws to state officials to promulgate rules and regulations concerning the enforcement of the laws soon convinced the manufacturers and packers that it would be much better to comply with the terms of a national law than to attempt to meet the demands of a number of state laws, which would not only present a multiplicity of regulations but would undoubtedly be conflicting in some instances. Accordingly when the Gould bill was introduced in Congress to amend the Food and Drugs Act so as to require the net weight, measure or numerical count to be plainly and conspicuously marked on the outside of food packages there was not sufficient opposition to prevent its passage, and after some changes it became a law March 3, 1913, and was one of the last acts signed by President Taft.

Aside from the weights and measures provision contained in the Food and Drugs Act, the amendment of March 3 is the second and most important step taken by Congress to exercise authority over weights and measures in interstate commerce, which it has ample power to do under the express authority conferred upon it by the constitution. The assumption of federal authority in this instance points out the proper method for the solution of other weights and measures problems; and the enforcement of this amendment, it is believed, will present convincing evidence of the judiciousness and necessity of federal regulation over matters of an interstate nature, or where the exercise of authority by the individual states would be conflicting, or unnecessarily cumbersome on account of its multiplicity.

The proper regulation of types of weighing and measuring apparatus is one of the problems referred to which could be regulated by the federal government more scientifically and better than by the individual states and with more economy to the manufacturers of apparatus. Much apparatus now sold is faulty in design, false in its indications, and would not be permitted in any other important country in the world. A number of the states have already adopted specifications which the manufacturers are required to follow in making the apparatus sold in those states. They are in many cases imperfectly drawn, and on account of their lack of agreement with one another, the manufacturers are required to change their construction for some states, thus increasing the cost without accomplishing any useful purpose. The need of proper supervision over types of weighing and measuring apparatus has been felt for some time by weights and measures officials and is now beginning to be appreciated by manufacturers. The effect of such supervision would be to eliminate from use types of apparatus which facilitate the perpetration of fraud, and poor apparatus of cheap construction; and would in general standardize apparatus and practises. Bills have been introduced in Congress from time to time to confer upon the Bureau of Standards the authority to pass upon types of weighing and measuring apparatus, but no law has yet been passed.

Another problem of far-reaching effect upon the interstate commerce of the country is the proper supervision of railroad track scales. This matter was recently brought to the attention of Congress by the Bureau of Standards, and its request for an appropriation of $25,000, which became available July 1, 1913, was granted. Out of this appropriation a special test weight car has been provided with which a number of railroad track scales have already been tested, disclosing large discrepancies and plainly showing the need of supervision. The purposes of this car are to provide, as far as practicable, official standards heretofore lacking for the testing and standardizing of railroad track, elevator and other scales, and to obtain data for determining what tests are adequate to insure reliable adjustment of such scales, and upon which may be based specifications for their construction and operation.

# THE STRUGGLE FOR EQUALITY IN THE UNITED STATES.

## V

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### The Courts and Property

THE constitutional safeguards which surround private property in the United States are exceptionally strong. Between confiscation and the multitude stand the state and the federal courts. In Cutting *v.* Goddard, decided in 1901, the Supreme Court held that a return of 10.9 per cent. on the investment is not unreasonably high and that a return of 5.3 per cent. is unreasonably low.[1] In decreeing the dissolution of the Standard Oil and the American Tobacco Companies, the same tribunal left the defendant companies in possession of everything which they had succeeded in amassing by unlawful methods. Nowhere in either of these decisions is there any hint that restitution ought to be made. On the contrary, every precaution necessary to conserve the property which monopoly control had garnered together was scrupulously observed. In the course of the Standard Oil decision, the Chief-Justice remarked "that one of the fundamental purposes of the statute (the Anti-trust Act) is to protect, not to destroy, rights of property."[2] No penalty was inflicted other than dissolution and the prohibition of acts violative of the statute. So far as constitutional guaranties are concerned, the most strenuous advocate of property rights could scarcely ask for anything more.

### I

Nevertheless, the extent to which the Supreme Court conserves the rights of property is easily exaggerated. The Dred Scott decision did not prevent the overthrow of slavery, and moreover without compensation. On the contrary, it hastened its downfall and proved to be the one thing from which the slave power might well have prayed to be delivered. Much comfort was extracted by an influential portion of the property-owning class from the income tax decision in 1895, but the cost of what was gained from that decision has seldom figured properly in the account. Probably no decision of the Supreme Court since the Civil War has excited so much dissatisfaction or fallen so flat. In the opinion of many the court as now constituted would find a way of upholding a similar measure even though the constitution had not been amended. To save the face of the court was the strongest argument

1 William Z. Ripley, ''Railway Problems,'' p. 578.

2 United States Supreme Court Reports, Vol. 55, Law. Ed., October, 1910, p. 652.

for proposing the income-tax amendment. But the decision of 1895 fanned the fires of social discontent. It unmasked the motives of those opposed to an income tax. On the one hand, are those well able to bear the burden of taxation upon whom a properly administered income tax would to a considerable extent rest. On the other hand, are the beneficiaries of protection who fear that an income tax will deprive them of one pretext for the maintenance of the tariff. The glaring injustice of any income tax apportioned among the several states according to population, in conformity with the court's decision, made such a tax impracticable. One effect was to discredit the court itself. Another fact had a similar effect. In its first decision, the court divided evenly on certain of the points at issue. After reargument it stood five to four against the act on these points. Far from conserving the social order, the in come-tax decision did quite the reverse.

Professor Daniels says:

> The decision or, more strictly, the decisions of the Supreme Court which killed the Income Tax of 1894 made a great deal of history, and unmade, or, at all events remade, a good deal of law. It certainly traversed legal expectation, it jostled the doctrine of *stare decisis*, it contravened previous decisions, and it discredited a good many dicta which had already become "blessed words" among authoritative text writers and accredited authorities on constitutional law. . . . The deliverance of the court can be explained only by reference to what has been happily termed "psychological climate." . . . The Supreme Court had reversed its own decision before, but except in the legal tender cases no modern decision had been reversed which bore very directly upon the stirring political issues of the day. But the court evidently had not been appealed to in vain upon the issue that the tax was a stride towards socialism, and the "weightier matters of the law" seemed to have been forgotten under the shadowy sense of dread which the dim specter of socialism invoked. The most venerable member of the court gave emphatic utterance to the feeling which moved him. "The present assault upon capital," said Mr. Justice Field, "is but the beginning. It will be but a stepping-stone to other, larger and more sweeping, till our political contests will become a war of the poor against the rich, a war constantly growing in intensity and bitterness." [3]

Probably the Dartmouth College case has been more often quoted than any other as indicative of the jealous care with which the Supreme Court safeguards property rights. But few decisions illustrate better the relativity of judicial decisions to the circumstances existing at the time and place. When the decision was handed down, business was still conducted on a very modest scale, and the era of the corporate form of business organization was yet to come. In view of the important respects in which the doctrine of charter rights has been modified in subsequent cases, it is probable that the decision handed down in 1819 would have been different if the industrial changes of the next fifty years had been foreseen. Some one has aptly said that the Supreme

[3] Winthrop More Daniels, *op. cit.*, pp. 199, 200 and 206.

Court follows the election returns. As it was, it appears that Chief Justice Marshall succeeded in bringing a majority of the court to his point of view only by means of methods which in the light of to-day are so high handed and questionable that they would hardly be tolerated for a moment.[4]

The potency of the courts to protect property rights depends upon public opinion. Respect for the law is not always at a maximum in the country having the most laws. "It is not the existence of statutes," writes President Hadley, "which makes murder a crime; it is the growth of a public opinion which makes the individual condemn himself and his friends, as well as his enemies, for indulgence in that propensity." The chance of convicting prominent business men under the criminal section of the anti-trust act until recently has been so slim that it was not worth while to bring suit. During the disorders attending the strike of employees on railways centering at Chicago in 1894, public feeling ran so high that the injunctions issued by the federal courts were not vindicated until much of the irreparable injury forbidden by the courts had been inflicted upon the railways and those dependent upon their services. The damages which the railways have since recovered by suits at law for the destruction of property are but a tithe of the losses which they sustained, to say nothing about the losses inflicted upon the public at large. When toll pikes in Kentucky were in public favor, the right of property in them was secure. When they come to be regarded as a "relic of barbarism," the courts were powerless to protect them.

Prior to the Civil War, many counties in Missouri issued bonds to subsidize the building of railways. The bond issues were loosely safeguarded, and some counties in which no railroad was built were saddled with a heavy debt. The people in these counties naturally opposed paying the interest and the principal of the debt, and went so far in some instances as to elect judges of the county court pledged not to make the necessary tax levy. The bond-holders accordingly sought a remedy at the hands of the federal court in Kansas City, Missouri. But in a number of counties public opinion was so set that the orders of the federal court directing the county judges to levy the necessary tax have repeatedly failed to command obedience. One of the accepted and well-understood duty of the judges in some counties has been a jail sentence for contempt of court. In some cases the judges have taken to the woods as soon as elected. The Supreme Court has held that a federal judge can not himself or through any official appointed by him make a tax levy. The utmost that can be done is to order a county official to levy the tax needed to pay a judgment, and to punish failure to comply

[4] Jesse F. Orton, "Confusion of Property with Privilege; Dartmouth College Case," *The Independent*, Vol. 67, 1909, pp. 392–97.

as contempt of court.[5] The upshot is that the decrees of the federal court have for years been in abeyance and the legal rights of the bondholders have not been enforced. This incident renders it more than doubtful whether the federal courts could have prevented a number of states from repudiating their debts even if the eleventh amendment had never been added to the constitution. In the words of Lincoln:

In this and like communities, public sentiment is everything. With public sentiment, nothing can fail; without it nothing can succeed. Consequently he who moulds public sentiment goes deeper than he who enacts statutes or pronounces decisions. He makes statutes and decisions possible or impossible to be executed.[6]

If the status of public opinion sometimes paralyzes the activity of prosecuting attorneys and nullifies the decrees of courts, it also occasionally enforces a higher standard of business conduct than the law requires. Numberless oral agreements are every day faithfully observed which can not be enforced at law. Many a man's word is as good as his bond. Every social group has a code of honor which in some respects exceeds the letter of the law. Probably "Wall Street" suggests a low order of cunning to most minds, and yet there is not place where certain kinds of contracts are more scrupulously observed. The whole fabric of credit so essential to modern business rests upon men keeping faith, and is in the main quite independent of the compulsory processes of the courts. Justice secured by means of litigation is frequently so expensive that it comes too high. Throughout the silver controversy the members of the New York Clearing House steadfastly refrained from paying their daily balances in silver, though Congress required the Clearing House rule forbidding such payments to be rescinded.[7] During the Civil War, Massachusetts paid the interest on her bonds in gold, "though it cost her sometimes nearly three for one to keep her faith."[8] More noteworthy was the maintenance of the gold standard on the Pacific Slope. Legally debtors in California had as much right to tender greenbacks in full discharge of their debts as in any other part of the country, but the fact that a man could not tender greenbacks without injuring his credit and losing standing among business men effectually prevented such conduct. Self-interest resulted in a higher standard of business honor than the law demanded. In like manner competition at the present time frequently compels a higher standard of efficiency and honor among men than the law requires.

It is difficult to see why any one with any practical experience of business should take the law of the matter as a guide. The law is a very cumbrous, slow

[5] I am indebted to the Dean of the University of Missouri for this information.

[6] "Debates of Lincoln and Douglas," *op. cit.*, p. 82.

[7] Horace White, "Money and Banking," fourth edition, p. 171.

[8] James Russell Lowell, "Prose Works, Essay on Democracy," Vol. 6, p. 11.

and inefficient machine for preventing robbery and other crimes on the part of rogues and burglars in the various forms in which they infest society. It makes no attempt to show how things should be done well. That is not its business. Any one who relies on the merely legal interpretation of his duties is only doing enough to keep him out of Wormwood Scrubs.[9]

Once more, when boast is made of the protection afforded private property by the courts, an important exception should be noted, namely, promissory notes. Congress has the right at any time to emit bills of credit and to declare them a legal tender in payment of pre-existing debts. The man who lends another one thousand dollars to-day is without any remedy at law if his debtor at the maturity of the loan tenders him depreciated paper money which Congress has clothed with legal tender power. In other words, a large class of property is in an important respect well outside the protection of the courts. The only remedy open to those opposed to debasing our monetary standard is political action. It was this remedy and this remedy alone that brought about the resumption of specie payments and subsequently prevented the free coinage of silver. Even if the final decision of the Supreme Court in the legal-tender cases had been adverse to the power of Congress to issue the greenback, a large portion of the community, including the great army of wage earners, would have suffered an irreparable loss before the decision was reached.

The property-owning interests dependent upon a protective tariff for their prosperity are in a position similar to the holders of promissory notes. The tariff schedules fixed by any Congress may be changed at any time without the slightest obligation to compensate those whose business interests are thereby disturbed. The courts can not be successfully invoked to stay the hands of Congress. Here as in the case of promissory notes the parties interested are limited to political action, and if the history of tariff legislation indicates anything it is that the remedy is more than adequate.

The case of the liquor traffic, a business in respect to which the police power of the state is subject to a minimum of restraint by the courts, illustrates the same point. The state may, if it deems wise, prohibit the manufacture and sale of intoxicating beverages without indemnifying any one for losses sustained. The liquor business is commonly regarded as disreputable. When run for profit, it is inconsistent with the public good and it is accordingly subjected to all sorts of restrictions. It is notorious that the business in many communities is conducted in flagrant disregard of law. Comparatively few states, however, go so far as to try to prohibit the traffic. In most communities the business flourishes and there is no lack of capital willing to assume the risks incidental to embarking in it. As in the case of protection, the

[9] Hartley Withers, "Stocks and Shares," p. 145.

political remedy is usually more than ample to safeguard the liquor interests.

## II

The theory of judicial control in the American constitutional system entitles the courts to a certain eminence, but it does not justify magnifying the judiciary to the exclusion of everything else. The courts are but one of several restraining influences to which the members of our legislative bodies are subject. "Things in possession," says James Russell Lowell, "have a very firm grip. One of the strongest cements of society is the conviction of mankind that the state of things into which they are born is a part of the order of the universe, as natural, let us say, as that the sun should go round the earth."[10] The members of our legislatures are no more exempt from the play of this influence than is the mass of the people who elect them. The man who is obliged to listen to arguments on both sides of a question is apt to reflect a moderate point of view. Responsibility also exerts a sobering influence. Besides, in most states political parties are so evenly balanced that other men ambitious for office, within as well as without the party, can easily take advantage of any serious mistake of judgment. Once more, the mass of bills introduced at the recurring sessions of our legislatures is such that none save those that are vigorously pressed stand much show of enactment. The average member likes to be considered a practical man, and therefore looks askance upon the proposals of crank reformers. Finally, in a political contest, the property-owning class is very resourceful in taking care of itself. It can see to it that its claims are ably presented. It can pay for printers' ink. It can command the support of men of influence in the community. It can hire effective advocates and attorneys skilled in the labyrinthine processes of the law. It has great power of endurance as an antagonist. Property has a certain glamor which enables it to make friends in unexpected quarters.

Nor does the referendum promise to lead to such radical departures as many fear. There is a vast amount of inertia in the multitude which makes strongly for things as they are. The masses of the people may be more conservative than the average member of a legislature. For this reason certain organs of the Conservative party in England favor the referendum. It may prevent extremists from getting what they want by playing off one party against another. Many people are unwilling to take the trouble to inform themselves upon measures proposed for reform. Others talk like progressives, but lose heart when it comes to vote. Many working people are as much averse to shortening the working day as are the owners of factories. Parents bent upon exploiting their children are opposed to the interference of the law. The boys upon the anthracite coal breakers like their jobs. It is noteworthy that the ex-

[10] *Op. cit.*, p. 36.

tension of the ballot to women recently in Illinois was done by the legislature and not by a referendum. The gaining of "votes for women" may render the electorate still more cautious going. The historic function of women has been to conserve the old rather than to initiate the new. In any event, some opponents of woman suffrage favor submitting the question to the women of the several states as the most effective way to defeat it.

It is possible that the advocates rather than the opponents of the referendum will find more cause for disappointment at the result. The people of Oregon in 1910 and 1912 as compared with 1906 and 1908 showed a disposition to go somewhat slower in assenting to measures submitted for their approval. Out of thirty-two measures submitted in 1910, twenty-three failed to secure popular approval.[11] In 1912, twenty-six out of the thirty-seven measures submitted failed of adoption. Of the thirty-seven measures submitted, fourteen were proposed amendments to the constitution, only four of which were adopted. As the number of measures submitted has increased, the percentage adopted has fallen.[12] Of one hundred and sixteen constitutional amendments submitted to the voters of the several states during 1886–1891, sixty-two were rejected.[13] Of ninety-nine amendments submitted during 1894–'96, fifty-three were rejected.[14] Of eighty-eight constitutional questions submitted to the voters of Michigan during 1835–1908, thirty-nine failed of adoption.[15] In Massachusetts affirmative action has been more common. Of sixty amendments submitted since 1780, only nineteen have been rejected.[16] The experience in Switzerland has been that many progressive measures when submitted to the people have been defeated.[17] Its effects have not been radical or socialistic, neither has its tendency been progressive.[18]

Few writers eminent in the world of letters during the closing years of the nineteenth century were so impressed with the evils of democracy as Lecky. To his mind a wide suffrage meant government by the more ignorant portion of the community, political instability, successful appeals to class jealousies and antipathies by the demagogue, the spoliation of the rich by the poor. And yet Lecky was inclined to view the

[11] Ellis Paxson Oberholtzer, "The Referendum, Initiative and Recall in America," pp. 397–412.

[12] George H. Haynes, *Political Science Quarterly*, March, 1913, pp. 19 and 32.

[13] A. Lawrence Lowell, *op. cit.*, p. 170.

[14] Ellis Paxson Oberholtzer, *op. cit.*, p. 163.

[15] John A. Fairlie, "The Referendum and Initiative in Michigan," *The Annals of the American Academy of Political and Social Science*, Vol. 43, 1912, pp. 155–158.

[16] A. Lawrence Lowell, *op. cit.*, p. 171.

[17] Jeremiah W. Jenks, "Governmental Action for Social Welfare," p. 58.

[18] A. Lawrence Lowell, *op. cit.*, p. 168.

referendum with favor. By disentangling issues from one another, by freeing them from the dominion of party and from coalitions of log-rolling politicians, he thought the referendum might "prove the most powerful bulwark against violent and dishonest change." He even went so far as to say "that its tendencies might be towards extreme Conservatism."[19] One of the leaders of the Labor Party in England, Mr. J. Ramsay Macdonald, thinks the referendum will enable reactionaries to single out certain measures for defeat and to interfere with a consistent policy of reform.[20]

Judging from the amount and the character of the opposition which the referendum at present excites in the United States, one might suppose that it is nothing less than revolutionary in principle. Yet it involves nothing with which the country has not long been familiar. It squares with the traditional American theory that sovereignty resides in the people. In calling constitutional conventions and in adopting new constitutions it has long been employed in most of the states. It is the usual method of amending our organic law. In the decade ending with 1908, 472 constitutional questions, nearly all amendments, were submitted to the people of the several states.[21] The movement now well under way merely extends the use of the referendum to legislative acts. I can see no objection to such an extension that does not apply with as much force to the right of the people to determine their organic law. The latter is the more fundamental and logically includes the former. If the right of the people to pass upon legislative questions is dangerous to liberty and property, the right to pass upon constitutional questions is still more dangerous, unless surrounded by more careful safeguards. It is evident that the electorate *en masse* of a large population can not formulate the details of either their statutes or their constitutions. But if they are incapable of passing upon the public policy embodied in the former, neither are they capable of passing upon the general principles embodied in the latter. "The fact is," says Professor Burgess, "that the political science of the modern world is still engaged in the task of working out the distinctions between sovereignty and government, and that political practise is in the transition period between the sovereignty of the government and the sovereignty of the people behind the government."[22] Much of the opposition to the referendum can only be understood in the light of this remark.

The argument that the referendum will lower the character of our legislative bodies is of doubtful validity. This has not been the effect

19 *Op. cit.*, pp. 22–34 and 276–294.

20 A. Lawrence Lowell, *op. cit.*, p. 158.

21 Ellis Paxson Oberholtzer, *op. cit.*, p. 477, quotes W. F. Dodd's work on "Revision and Amendment of State Constitutions" to this effect.

22 *Political Science Quarterly*, Vol. 13, 1898, p. 203.

upon our constitutional conventions. The personnel of these conventions is far superior to that of our state legislatures. While many of the latter have gained a reputation as fountains of political debauchery and have declined in influence, the former have remained in high repute. A seat in a constitutional convention is still an honor.

> The best men in the community are still willing to serve in it, no matter at what cost to health or private affairs. I can not recall one convention which has incurred either odium or contempt. . . . In looking over the list of those who have figured in the conventions of the State of New York since the Revolution, one finds the name of nearly every man of weight and prominence; and few lay it down without thinking how happy we should be if we could secure such service for our ordinary legislative bodies.[23]

The demand for the referendum is the result of the deterioration which our state legislatures have already undergone.

Most of the objections to a larger measure of popular rule are merely notes of caution. The proper metes and bounds can only be determined in the light of further experience. In the mean time, it is the place of every intelligent man to keep an open mind. No plan of government is a finality. Our direct primary laws are still in the experimental stage. Some of them have been enacted by machine politicians with a view to discrediting them and are capable of great improvement. Even the fundamental guaranties of our federal and state constitutions need to be adapted to changing conditions either by interpretation or by formal amendment. The constitutional prohibition in Pennsylvania which prevents a law requiring wages to be paid in money may have once conserved the liberty of the individual, but such a prohibition to-day secures the form without the substance of liberty.[24] Whether a given guaranty is fundamental or not is a matter upon which there may easily be differences of opinion. To hold that constitutional guaranties are immutable and that the majority after due deliberation has not the moral right to change them is to take them outside the realm of reason and discussion.

On constitutional matters practically no one questions the referendum. On local matters, such as the liquor question, increasing the bonded debt of a city and granting franchises, where the issues are "simple and familiar to the voters," it has an acknowledged field of usefulness. The extension of the referendum to state-wide legislative acts is at the present time the bone of controversy. A century ago, however, the ratification of state constitutions by popular vote was viewed with similar misgivings. It was not till 1840 that this practise was generally recognized. At the outset, the state legislatures called

[23] Edwin L. Godkin, "Unforeseen Tendencies of Democracy," p. 142.

[24] William Draper Lewis, "A New Method of Constitutional Amendment by Popular Vote," *Annals of the American Academy of Political and Social Science*, Vol. 43, 1912, pp. 315–316.

constitutional conventions without any higher sanction.[25] The federal constitution was ratified by representatives of the people and not by popular vote. To-day, however, the ratification of amendments to the constitution by the legislatures of the several states is an anachronism. As applied to legislative acts, the referendum can have only a negative effect. As already noted, it frequently makes for things as they are rather than for needless change. A serious objection is that it may embarrass the conduct of public affairs by withholding necessary appropriations. The voters are sometimes penurious in voting the public money. On two occasions, appropriations for the state university in Oregon have been held up until approved by a referendum, the teaching staff in the meantime performing its duties without pay. Such experiences tend to repel efficient teachers. The educational advantage to the voters hardly compensates for the interference with efficiency. Such occurrences are, however, not a necessary feature of the referendum. In Ohio, "laws providing for tax levies, appropriations for the current expenses of the state government and state institutions," are not subject to the referendum. The legislature is also empowered to exempt "emergency laws necessary for the immediate preservation of the public peace, health or safety" from a referendum by a two-thirds vote. Similar provisions exist in many other states.

The small vote polled on constitutional and legislative referenda as compared with the vote for candidates often excites remark. Probably it indicates that many voters are more interested in men than measures. It also points to the fact that our political canvasses are largely contests between individuals seeking the emoluments of public office. Electioneering is so conducted as to arouse partisan zeal. The appetite of hungry spoilsmen aided by automobiles gets out a vote that is not particularly well informed. Moreover, referenda seldom get much newspaper notice. Except in Oregon, the voter is usually left entirely to his own devices to inform himself. Finally, referenda are overlooked by many voters because they occupy an inconspicuous place on the ballot. The vote cast upon such questions in Illinois has been greatly increased by placing them upon a separate ballot. A similar plan in Idaho has almost doubled the percentage of the total vote cast on constitutional amendments.[26]

In the opinion of some writers, the initiative is nothing less than revolutionary. "Of all the proposals that have been brought forward in the name of direct democracy, the initiative is the most preposterous

[25] Charles A. Beard and Birl E. Shultz, "Documents on the State-wide Initiative, Referendum and Recall," pp. 15–19.

[26] W. F. Dodd, "Some Considerations upon the State-wide Initiative and Referendum," *Annals of the American Academy of Political and Social Science*, Vol. 43, 1912, p. 213.

and the most vicious," remarks President Butler.[27] In view of the diverse forms which the initiative takes in the several states, this condemnation is altogether too sweeping. One's judgment should be governed by the concrete form which the initiative takes. In Oregon, a measure goes directly to the voters in the form in which it is initiated. In Ohio, it is first considered by the legislature. If not enacted into law within four months, or if passed in an amended form, it is submitted to the people in either its original or its amended form, provided a supplementary petition "signed by not less than three per centum of the electors in addition to those signing the original petition" is filed with the secretary of state. In Oregon, eight per cent. of the legal voters are required to initiate a measure; in Wyoming, the plan submitted to the voters in 1912 required twenty-five per cent. In Missouri, an initiative petition must be signed "by not more than eight per cent. of the voters in each of at least two thirds of the congressional districts in the State." The larger the population of a state the more difficult it is to secure the required number of petitioners. In Michigan, more than twenty per cent. of the voters "voting for secretary of state at the preceding election of such officer" are required to initiate a constitutional amendment. The petition must be signed at a regular registration or election place and the signatures must be verified by the registration or election officers. No amendment can be submitted to the people if the legislature disapproves. Finally, an affirmative vote of not less than one third of the highest vote cast at the election for any office is required to adopt such an amendment.[28] A movement that is marked by so many signs of caution offers little occasion for alarm to the owners of property.

A common objection to the referendum and the initiative is that they will destroy representative government. By a similar course of reasoning, namely, by excluding everything but one fact from the mental horizon, one might prove that the earth is destined soon to fall into the sun. I am not aware that the most radical advocates of direct democracy propose to do away with representative government. The yearly grist of legislation is so large as to render such a thing impossible. The chief object of direct democracy is to render our representatives more truly representative. If our legislative bodies were the deliberative bodies they are supposed to be, the demand for the referendum and the initiative would hardly have arisen. Many bills are originated by interests outside of the legislature and are rushed through in the closing days of the session without opportunity for amendment or debate. Instances of minority rule through laws enacted by a majority

[27] "Why Should We Change Our Form of Government," p. 25.

[28] Charles A. Beard and Birl E. Shultz, *op. cit.*, pp. 80, 203, 169, 178–179; Ellis Paxson Oberholtzer, *op. cit.*, p. 397; "The Constitution of the State of Ohio," published by Chas. H. Graves, Secretary of State, 1913.

of our legislative assemblies have not been uncommon. As a result, there has long been a tendency to shackle our legislatures with more stringent constitutional restrictions. Numerous statutory enactments have been written into the organic law of many of the states which the legislature can not change. Provisions in the statutes of some states are often found in the constitutions of other states. The referendum and the initiative are another device to prevent an abuse of legislative power.

President Woodrow Wilson says:

> Among the remedies proposed in recent years have been the initiative and referendum in the field of legislation and the recall in the field of administration. These measures are supposed to be characteristic of the most radical programs, and they are supposed to be meant to change the very character of our government. They have no such purpose. Their intention is to restore, not to destroy, representative government. . . . If we felt that we had genuine representative government in our state legislatures no one would propose the initiative or referendum in America. They are being proposed now as a means of bringing our representatives back to the consciousness that what they are bound in duty and in mere policy to do is to represent the sovereign people whom they profess to serve and not the private interests which creep into their counsels by way of machine orders and committee conferences. The most ardent and successful advocates of the initiative and referendum regard them as a sobering means of obtaining genuine representative action on the part of legislative bodies. They do not mean to set anything aside. They mean to restore and re-invigorate, rather.[29]

Our legislative bodies sometimes yield to the passions of the hour, but the cowardice and irresponsibility which lead to this result are to some extent induced by the fact that the courts may set aside what the legislature enacts. The contention that the referendum will lower the standing of our legislatures is open to question, but there can be no doubt that judicial control has promoted trifling on the part of our legislative bodies and undermined their authority. So long as the Interstate Commerce Commission was not clothed with the substance of power, the railways occasionally treated it with contempt by waiting to present their side of a controversy until it was taken up by the courts. In like manner, judicial control lessens the reliance of property owners upon political action and causes undue reliance upon the judiciary. It seems probable that many members of our legislatures would treat the railway interests with more consideration if they knew that legislative indiscretion would not have to run the gauntlet of the courts.

Notwithstanding the undermining influence of judicial control upon legislative authority, the railways have found political action by no means unavailing. It is notorious that the legislatures of many states have done the bidding of the railways in practically everything that has concerned the railway interest. Likewise, our municipal governments

[29] William Bennett Munro, "The Initiative, Referendum and Recall," pp. 87–88.

have frequently been dominated by the public service corporations. The story related of a member of the Pennsylvania legislature, who, on a certain occasion, moved that if the Pennsylvania railroad has no more business to transact, the legislature do now adjourn, is typical of a situation that has been more or less general. If the railway and other corporations have not always been treated fairly by the public, it has sometimes been because the corporations by pressing their advantage too far have brought about a revolt from corporate rule. A high financial authority, *The Commercial and Financial Chronicle,* seldom commends the tendency of government to interfere with business. It maintains that the railways have not been getting fair treatment at the hands of the Interstate Commerce Commission. But concerning state regulation of rates, it remarks:

> Immediately preceding the panic of 1907 the states were very active for a time in reducing rates, but as soon as railroad revenues commenced to fall off, the States began to see the logic of the situation and in most cases changed their policy. They desisted from further attacks on the railroads. The local newspapers came to the rescue and pointed out how seriously the railroads were suffering and how detrimental to the best interests of the State this was. Popular sentiment changed and attacks upon the railroads in large measure ceased. Thus it was demonstrated that, after all, the railroads had little to fear from State action.[30]

One of the important functions of corporations, according to Professor Burgess, is to save the people from paternalism by acting as a makeweight against the state.[31] There can be no doubt that corporations serve this purpose. By enabling individuals to combine their several resources and talents, they preempt a large field for individual enterprise which only the state would otherwise be equal to undertake. But it is an open question whether this will prove true in the long run, so strong is the political influence which corporations can bring to bear against the public interest. The problem of keeping corporate action within proper bounds is so difficult that the upshot may be that the state will be driven to take over certain industries and run them on its own account.

30 June 14, 1913, p. 1657.

(*To be continued*)

31 *Op. cit.,* pp. 203–204.

# EUGENICS AND EUTHENICS[1]

By Professor MAYNARD M. METCALF

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THE privilege of claiming your attention for a few minutes is doubtless given to me as a biologist, and I shall speak chiefly of the biological aspects of the subject, leaving to others to discuss its sociological aspects.

There are three phases of the problem of human betterment—culture, eugenics and evolution—and these need to be carefully distinguished. They are commonly confused in the minds of those who have given little thought to the biological aspects of the problem, and such confusion is likely to lead to misdirected effort. The biologist who makes no claim to be a sociologist may make a few suggestions to which the student of social problems may well give heed.

Human betterment may be secured through work for the relief of distress, through education of the individual, by inspiring him to action upon a higher moral plane. By the cumulative effects of such culture, generation after generation, great social advance may be made. It is by this method that our great advance in civilization has been secured. This is, of course, work of the greatest value, promoting profoundly human happiness and social progress. It needs no defense. It makes a strong natural appeal to every normal man. If effort for the comfort of domestic animals is recognized by us all as of worth, how much more must we approve all intelligent endeavor to advance human welfare. In nothing that I shall say would I wish to be interpreted as lacking in appreciation of and enthusiasm for such individual and social culture. Contributing to the happiness of one's family and neighbors, promotion of normal living among them, is a life motive worthy of any man, and when we realize that the betterment thus effected need not cease with the present generation, but may improve the social conditions under which all following generations shall live, this ideal becomes glorified.

But in all the centuries of known human history, while wonderful advance in individual conduct and social relations has been secured through the cumulative effect of the cultural effort that has been made, there has been little, if any, advancement in innate human character. There has been through all the centuries little, if any, improved inheritance for the race as a result of the many generations of culture. I have before written:

> We have no reason to believe that the progress in culture, secured by education in one generation, will directly improve the innate character of the chil-

[1] Presented before the National Conference on Race Betterment.

dren of the next generation. Were the effects of education inherited, human evolution should be rapid, but it has been slow; how slow perhaps few of us realize. We speak with pride of the advance of human civilization, of our progress in the arts and in useful knowledge, of the improvement in morals and the growth of altruism, and this all makes us blind to the fact that since the dawn of history there has been no clearly recognizable evolution of mankind. We reach larger results in the problem of life than did our progenitors five thousand years ago, but we are able to do so because we build upon their experience and that of all the generations between.

Have we much greater innate powers? Are we at birth endowed with characters having much higher possibilities and much higher tendencies physically, intellectually and morally? Have we to-day men of much greater physical prowess than the ancient conquerors of the world, than the builders who constructed the monuments of Egypt? Have we more adventurous spirits or more successful explorers than the Phœnicians, who without compass sailed the ancient seas, reaching the whole Atlantic coast of Europe and the British Isles, also passing southward even around the tip of Africa? Are there among us to-day men of keener inventive genius than the one who first used fire, or the inventor of the lever or of the wheel or than the man who first made bronze or smelted ore? Our modern engines have been invented screw by screw by successive builders, each building upon the others' work. Have we to-day men of much larger legal and social understanding than the ancient lawgivers who forged the legal systems which still are the basis of our most enlightened governments? Have we poets whose genius greatly transcends that of Homer, or of the authors of the books of Job and Ruth? In esthetic appreciation, and in the power of artistic expression in sculpture and architecture, we are degenerate compared with the Greeks.

Even in innate moral character have we greatly advanced? We are *learning the lesson* of altruism, but *are we born* with a sturdier moral sense? If we could take a hundred thousand infants from London or Chicago and, turning back the wheel of time, place them in the homes of ancient Babylon, would they reach a higher standard of righteousness or of altruism than their neighbors? How little evidence we have of real evolution of mankind since the first emergence of the race from the darkness of prehistoric times!

But though we accept the statement that innate human character can not be improved by the direct inheritance of the effects of culture, there still remains to us the eugenic method of procedure, which, if it can wisely be applied, may result in improvement in the stirp, in the real essential innate character. This is an ideal that fires the imagination—the breeding of a race that shall be strong and wholesome, physically, intellectually and morally; men who shall be decent because they are inherently decent, not because by training they restrain their evil tendencies; a race from whose fundamental character the evil tendencies are actually removed. This is a social ideal higher even than was apparently present to the mind of Jesus.

Is this ideal—of a race of inherently wholesome men—utterly chimerical, or is there a way of approaching it? No positive, indubitable answer can now be given to this question, for scientific study of heredity has not yet given us extensive knowledge of the biological, especially of the psychological phenomena of inheritance.

This second part of the problem of human betterment, real race betterment, is a problem of good breeding, not one of culture. This problem of good breeding has two somewhat distinct aspects that are seldom clearly distinguished. There is first the problem of bringing the race average nearer to its present best by eliminating the less desirable and breeding from the best. This is the problem of eugenics as ordinarily considered. But there is the added problem of securing further true evolution of the race, raising the present best to a better.

We see thus the three aspects of the problem of human betterment: first, human culture, whose effects are cumulative through training from generation to generation, though not inherited; second, race-betterment through breeding from the best and eliminating the more undesirable, thus raising the general average toward the best type of manhood as we know it; third, the problem of securing true evolution beyond the point of the best yet experienced among men.

The problem of human culture is social, not biological. The problems of eugenics and evolution are primarily biological, but can be approached only if social conditions allow the application of biological method. It is necessary to emphasize cultural effort, for it is essential that the good breeding of the future human race be in the midst of a controlling atmosphere of highest altruistic idealism. Let us note for a moment some elements of the biological problem.

I can not stop to describe the microscopical structure of germ cells and their nuclei; the fact that the nuclei contain chromosomes in definite number which are the instigators of physiological action and the controllers in heredity; that the chromosomes in each nucleus fall into diverse categories physiologically, there being two chromosomes of each physiological type, one derived from the male parent and one from the female parent; that the different regions of a single chromosome may have different physiological values, and that in the division of nuclei the chromosomes split in such a manner that each daughter cell receives half of each specialized bit of each chromosome; that before fertilization one chromosome of each physiological pair is thrown away, and that in fertilization the full double character of the nucleus is restored. Of course, without knowledge of these structures in the germ cells and of their behavior in reproduction, one is not ready to begin to think of problems of inheritance. Familiarity with these fundamental facts not only helps one to escape many errors into which so many of the uninitiated fall, as, for example, the belief in the inheritance of the effects of culture, that is, of acquired characters, but it is essential as a guide to every step of one's thinking in this field. But I must assume that these are familiar matters to you all.

Recent studies in heredity have demonstrated that there is a sharp distinction between qualities that are heritable and others that are not heritable. We name the former stable characters, the latter unstable, or fluctuating characters. New qualities are arising from generation to generation through variation. These variations may similarly be classed as stable variations, or mutations, and fluctuating, or unstable, variations. No result can be reached by breeding with reference to unstable variations or qualities, for they are not inherited. Qualities belonging to the unstable type can not be fixed by breeding. They are, therefore, without significance in the problems of eugenics and evolution. It is impossible, however, to discern whether an observed quality is of the stable or unstable type until one follows its behavior in inheritance.

Another fact of the greatest importance to remember is that there is probably no such thing as inheritance of vague general resemblances, but that inheritance is apparently always particular, definite, so-called unit qualities being the things inherited. The character of any individual is built up of a complex multitude of such unit qualities, each heritable separately, and the character of an individual depends upon the combination and interaction of the unit qualities that have been passed down to him from his parents, grandparents and other progenitors.

In the light of these facts, what is the essential problem, first in eugenics, then in evolution? The eugenics problem is accurately to determine the desirable unit qualities, which must be of the stable type, and to combine and fix them in the race by breeding, eliminating at the same time the undesirable unit qualities. It is the problem of finding the exact units of inheritance, and of so fixing and combining, by breeding, these valuable units in the individuals of the coming generations that we shall have a more wholesome innate character in mankind. The evolution problem is to find among the multitude of diverse human traits *new* desirable unit qualities of the stable type, often only in their beginnings, and to perpetuate these by breeding.

The Galton-Pearson school of English students are willing to waive accurate analysis of inheritance units, but the real problem will not be solved until we know whether the human qualities with which we wish to deal, the intellectual and moral as well as the physical, do follow the Mendelian principles in inheritance, and until we have analyzed the Mendelian qualities to their units. We have a notable example of failure to secure permanent valuable results in attempting to breed from individuals whose valued character had not been analyzed to its unit qualities. At the Agricultural Experiment station in Orono, Maine, many years of effort were given to securing a strain of fowl which would lay an unusually large number of eggs. Mere breeding from hens which laid many eggs was not found to be enough. The quality of high fecundity could not be fixed in the strain. Selection had to be continued in each generation or reversion to the general average would occur. It was only after Raymond Pearl's masterful experimental analysis of fecundity in fowls into its three physiological unit characters, and his combining of the three units into one individual, that it was possible to secure a strain in which high fecundity was a fixed character. In breeding humankind the manipulation of unanalyzed qualities might prove as futile as the earlier experiments at the University of Maine. On the other hand Burbank, in his breeding experiments, has reached some permanent results, though he has never scientifically analyzed into their units the desirable qualities he has succeeded in combining and fixing. But in each case he has dealt experimentally with many thousands of individuals and has reached success in but a small proportion of his attempts. His methods offer little chance of success in human breeding.

Even one wholly unfamiliar with the subject can see at once that the mere outlining of the biological problems of eugenics and evolution is wholly impossible in a limited paper such as this. Yet this very fact points the chief moral I wish to urge.

We are at the very beginning of our knowledge of heredity. Few of the myriad of unit qualities in mankind, or other animals, have been identified and defined. We know some, perhaps all, the units of hair color and eye color, we know some of the units of shape of hair, and a few other such comparatively simple qualities. But, as yet, we are merely entering the pass that opens on to the broad fields of knowledge of inheritance. We have analyzed a mere handful of the simpler physical unit qualities. We know nothing, as yet, of psychic unit qualities. We can not even be positive that the inheritance of psychic qualities is by definite units which follow the so-called Mendelian laws of inheritance. That intellectual qualities, and moral stamina, are heritable seems indicated, but the parallelism between their mode of inheritance and that of such a thing as hair color, however probable, is as yet not definitely demonstrated. It is possible that most psychic qualities are too complex ever to be sucessfully and completely resolved into their heritable units.

How much progress, then, may we hope for. We don't know, and we can not know, until we have had decades, perhaps centuries, of further study of these most intricate problems. By the biologist, trained through the study of evolution to think in geologic epochs rather than years, the dawn of a new day for mankind is foreseen. But to the sociologist, whose chief business is to apply our knowledge to present conditions, the whole subject is of much more limited interest. Aside from a few very limited aspects of negative practise of eugenics, the whole subject is, as yet, of little social significance. The prolonged labor of hundreds of special students is needed before this matter, which already is of the keenest biological interest, can become of the greatest social moment. We must cultivate a little of the patience of God. It is perhaps unfortunate that so much attention from laymen is focused upon this great field of research. The man of science needs to work quietly, patiently, doggedly, without too much thought of so-called practical value to follow from his studies. He is painting the thing as he sees it for the God of things as they are, and he is fortunate, in a way, if he can find a separate star where he may work undisturbed by the too eager interest of the crowd who clamor to know the significance of each brush-stroke.

Shall we then attempt no practical application in eugenics of the little knowledge of inheritance which we have already attained? For myself, I am in doubt. A number of states are making laws for the sterilization of certain undesirable classes, and are making the enforcement of these laws subject to the "expert" advice of a board composed generally of physicians. As a matter of fact there are very few states in this union which have among their citizens men capable of exercising expert judgment in these matters, and these men are not physicians, but biologists engaged in studies of heredity. Furthermore, in but few individual instances are there genealogical inheritance records which can serve as the basis of such expert opinion.

One thing, however, of the greatest practical value we can do. We can promote in every possible way the gathering and safe filing of human inheritance records, which in the future will serve as the foundation of such practise of eugenics as shall prove wise and practical. I can in imagination see the day when the compilation of inheritance data for each citizen will be compulsory, and when the files of these records will be the most valued of all state documents; when no marriage license will be issued except after the most careful scrutiny of the inheritance records of each contracting party by trained students of inheritance; and when the state will debar from marriage those whose children will be a burden to the state. The bearing of children is, of course, not an individual right, but a social privilege, and in time it must come to be so recognized.

With eugenics as our goal, with a hope of ultimately greatly improving the fundamental character of the race, let us cultivate patience, allowing time for the sure grasp of the phenomena and relations in heredity, before attempting by law any but the most limited applications of its principles to human marriage. Let us promote the view that social welfare, not individual comfort, is the ultimate criterion in marriage, and meanwhile let us actively promote the gathering and preserving of inheritance records for *all* persons, thus providing data for intelligent practise of eugenics in coming generations. We can at once insist upon the gathering of such data for all persons in our state penal institutions, almshouses, hospitals, asylums, etc. I am told that the city of Rochester is doing this with its public school children. We can urge the gathering of such data by privately controlled institutions of similar purpose. We can urge right-minded individuals everywhere to supply such data as to themselves and their families. But this will still fall far short of our need, for those who are contributing the most children to the coming generation will be the last voluntarily to supply the desired data. Nothing short of a state system of compulsory gathering of data for all individuals can serve as an adequate basis for such negative eugenics as it may in time be wise to enforce by law. But such compulsory gathering of data can not now be had. There must first be much education of general sentiment, and there must be trained students to take the records.

That observant naturalist, Oliver Herford, speaking in the supposed person of a crab, recently said:

> Be sure you are right
> Then go sideways for all you are worth.

I am asking for more time for the man of science to do his work before we insist upon applying too widely his results, lest in such application of uncertain scientific data we find ourselves making crab-like progress.

But I can not close with such a negative word. There are positive aspects of the matter which deserve the chief emphasis. Let me again urge that among the great needs must be recognized first scientific study of the principles of inheritance, and for this liberal financial support should be had; and second the cultivation of the realization that in marriage it is ignoble to seek the happiness only of the man and wife and to forget the character of the children and through them the welfare of society. Our poets and prophets, as well as our men of science, must open men's eyes to the beauty and worth of the social ideal in the family. Though we have advanced so short a way in the discovery of the phenomena and principles of inheritance, and though we have accurate inheritance tables for so few individuals, we can still clearly discern that marriage of certain individuals is unsocial. To what extent the state can now intervene to prevent such marriage is a question which needs careful detailed study, and is not an appropriate question for discussion in this brief general paper. But aside from this question of the limits of state action, we must emphasize the vital need of cultivation of the social point of view in this most vital of social institutions, the family, and the need now to gather the data upon which eugenics may in the future be based.

# THE PSYCHOLOGICAL LIMIT OF EUGENICS

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THE rapidity with which the eugenic idea has spread is little short of wonderful, and its value can not be overestimated. However, this value has been not only and not chiefly for what it has claimed for heredity, but for the attention it has turned towards sanitation and hygiene.

This is a time of great social unrest and any panacea which offers to solve our problems is eagerly embraced. Eugenics has volunteered for the service, which accounts, in part, for its rapid spread. A second reason is its simplicity. Only one principle is required to dispose of all problems. In this connection Dr. C. A. L. Reed says:

> So vigorous, aggressive and all-pervading have become the demands upon the "science of being well born," that many have come wrongly to think that there is no problem other than heredity in the great problem of race culture.[1]

It is the object of this paper to show that even if a perfect eugenic system were in vogue, practically every social problem which we are now trying to solve would still remain, and I wish also to urge that in spite of what good it may have done, it has also done a very great harm in diverting attention from the really fundamental problems which underlie the question of race improvement.

The cocksureness of the eugenist is illustrated by the following quotation from Alexander Graham Bell:

> The individuals have the power to improve the race, but not the knowledge what to do. We students of genetics possess the knowledge but not the power; and the great hope lies in the dissemination of our knowledge among the people at large.[2]

In similar strain, but more comprehensive and more confident, we find Davenport saying in a magazine article:

> To the eugenist heredity stands as the one great hope of the human race, its savior from imbecility, poverty, disease, immorality.[3]

Let me quote further from Davenport's book, "Heredity in Relation to Eugenics."

> Man is an organism—an animal: and the laws of improvement of corn and of race horses hold true of him also. Unless people accept this simple truth and let it influence marriage selection, human progress will cease.[4]

1 *Lancet-Clinic*, January 3, 1914.

2 *Journal of Heredity*, January, 1914, Pl. 1.

3 C. B. Davenport, Pop. Sci. Mo.

4 P. 1.

Again:

> Perhaps the best definition of feeble-minded would be: "deficient in some socially important trait," and then the class would include also the sexually immoral, the criminalistic, those who can not control their use of narcotics, those who habitually tell lies by preference, and those who run away from home and school.[5]

Again:

> A settlement worker in New York City inquired into the meaning of a particularly unruly and criminalistic section of his territory and found that the offenders came from one village in Calabria known as the "home of brigands."[6]

The implication here is that the germ plasm in Calabria is bad. Finally, comparing the influence of the criminals who were sent to Virginia from England he says:

> Soon better blood crowded into Virginia to redeem the colony. Upon the execution of Charles I. a host of royalist refugees sought an asylum here and the immigration of this class continued even after the Restoration. By this means was enriched a germ plasm which easily developed such traits as good manners, high culture and the ability to lead in all social affairs—traits combined in a remarkable degree in the first families of Virginia.[7]

Please remember that I am not denying a great deal of good in this movement, but too little attention has been given to either psychology or sociology by the eugenists, and unjustifiable conclusions have been drawn. The vogue of these conclusions is likely to delay progress by putting our thinking back twenty years, since which time the sociologists have been patiently building up the data of social psychology.

After the theory of evolution had been pretty thoroughly understood, the Spencerian idea of its universal application was eagerly appropriated. It was simple and comprehensive. If we found a condition of social inferiority the explanation was, "a lower stage of evolution." A race was less enlightened and thus proved its biological inferiority. It was a fine case of reasoning *post hoc ergo propter hoc*. In my opinion the reasoning in the quotations I have just given is of the same sort. "A band of brigands, a bad heredity." No one would be more glad than the sociologist to find a simple explanation of social phenomena, but there is none, and, to the minds of most sociologists, I venture to say that, instead of being the one hope, eugenics barely touches the problem of fundamental race improvement, although it has a definite place.

In 1893 Huxley in his lecture on "Evolution and Ethics" sounded the warning against making too close connections between the physical and the social values. He said:

[5] P. 9.
[6] P. 183.
[7] P. 207.

> There is a fallacy . . . in the notion that because on the whole plants and animals have advanced in perfection of organization by means of the struggle for existence, and the consequent survival of the fittest, therefore, men in society, men as ethical beings, must look to the same process to help them towards perfection. . . . Social progress means a checking of the cosmic process at every step and the substitution for it of another, which may be called the ethical process; the end of which is not the survival of those who may happen to be the fittest (in the respect of the whole of the conditions which obtain), but of those who are ethically best.[8]

The eugenist would say that he is in full agreement with that statement, but he seems to think that the inheritance of these ethical qualities follows the same laws as the inheritance of biological qualities. Man may be bred for qualities just as the race horse is bred, but he may not then fit social conditions any better than a race horse fits plowing. It is of interest and biological value to discover the verification of Mendel's law in the inheritance of eye color and stature, but it has no more social significance than whether Mendel's giant or late peas tasted the better. Many of the other data collected belongs in the same class. They belong to the world of description, while good and bad belong to the world of appreciation and value and are subject to entirely different laws. This is the idea which no one seemed to understand, offered by Dr. Richard C. Cabot last fall at the meeting of the Society of Sanitary and Moral Prophylaxis, when he insisted that there is no necessary relation between "the rules of sanitation and the commands of morality."[9]

For purposes of argument I am willing to grant that imbecility and some diseases are sufficiently pathological to justify some eugenic measures, though some brief could be made for even the feeble minded, but every other one of Dr. Davenport's catalogue I will not grant. Consider some of them: "poverty, sexually immoral, criminalistic, those who can not control the use of narcotics, liars, and those who run away from home and school, good manners, high culture." A few of these may be related to imbeciles, but so far as they constitute social problems only a very small per cent. of them are the result of biological abnormality, and yet they represent conditions that seriously handicap race improvement.

Please keep this list in mind while we turn to another consideration. There are two technical terms in sociology which are gaining increased significance. They are *social control* and *mores*. The latter is one of the methods of the former. Mores was the word used by the late Professor Sumner, of Yale, to indicate the mental and moral environment into which a child is born and which he accepts as ultimate intellectual and moral authority. The widest variety of racial and social expressions must be explained by means of this post-natal psychological in-

[8] D. Appleton and Company, pp. 80, 81.

[9] See *The Survey*, October 25, 1913.

heritance. Professor Ames, of Chicago, indicates something of the process of its acquirement:

Every human being, if he is to live at all, is, from infancy, surrounded and cared for by persons. These persons fit into and help constitute a social group. The child is nourished, sheltered, guided and disciplined by this human environment. All objects and influences are mediated by the persons near him. His very sensations are determined and modified by them.[10]

The old-time evolutionist and the modern eugenist alike make little of social control in their effort to make clear the biological control of social processes. To them environment is merely external.

Let us now turn briefly to the list quoted from Davenport: Poverty is a problem, but we may ask in the words of Professor Cooley, of Michigan:

What shall we say of the doctrine very widely, though perhaps not very clearly, held that the poor are the "unfit" in course of elimination? . . . The truth is that poverty is unfitness, but in a social and not a biological sense. That is to say, it means that feeding, housing, family life, education and opportunity are below the standards that the social type calls for, and that their existence endangers the latter in a manner analogous to the presence of inferior cattle in a herd endangers the biological type. . . . But since the unfitness is social rather than biological, the method of elimination must also be social, namely, reform of housing and neighborhood conditions, improvement of the schools, public teaching of trades, abolition of child labor and the humanizing of industry.[11]

The subject of sexual immorality is absorbing our attention these days. Flexner says that it

plainly is absurd to speak as if women took to prostitution simply because they were marked out for a vicious life by innate depravity or even forced into it by economic pressure.[12]

If this kind of immorality were inherent we should, according to their own confessions, begin with the elimination of the greatest moral teacher of the early church, St. Augustine, and the greatest stimulator of modern social ideals, Count Tolstoy. The sex mores of Russia today are very different from those of America, and from those of Tolstoy's youth, and from what they will be a generation hence, all without the slightest help from eugenics, solely by the psychic force of social control. To be sure a part of the prostitutes are feeble minded, but even they are prostitutes largely as a result of the mores of their group and the commercial demand for their services.

As to the criminalistic, Lombroso with great pains made an anthropological description of the criminalistic type, but scarcely a criminologist in Europe or America to-day accepts his conclusions, and the modern science of penology is based on the system of social control.

[10] *Psychological Bulletin*, VIII., p. 407.

[11] C. H. Cooley, "Social Organization," pp. 294, 296.

[12] Abraham Flexner, "Prostitution in Europe," quoted from *The Survey*, January 17, 1914.

The same is true of the use of narcotics. With the exception of the few diseased who need special care, drunkenness is the product of group mores. The most drunken people in the world are undoubtedly the husky Russian peasants.

When it comes to lying by preference, I fear that none of us would escape, though most of us have painfully learned another way, while our yellow newspaper reporters still remain.

And as for running away from home and school, we might say that every normal boy has the tendency, and there are excessive cases like that of Mr. S. S. McClure, who tells us in his autobiography that he barely escaped being a tramp, in spite of which fact he has done some things for race improvement.

We need no germ plasm to explain the difference between "the first families of Virginia" and the poor white trash. That is exactly the sort of thing that mores explain.

But there are much more fundamental obstacles to race progress than these, and I can see no way in which eugenics can help them. Such forces as social classes, race prejudice, industrial strife, the social and economic position of women, are psychological problems of fundamental importance.

Social classes are not born, they are made. In this connection Lester F. Ward, the leading American sociologist, said:

> A certain kind of inferiority of the lower classes to the upper is admitted. There is a physical inferiority and there is inferiority in intelligence. This last is not the same as intellectual inferiority. Their physical inferiority is due entirely to the conditions of existence. As a subject race, as slaves, as overworked laborers or artisans, as an indigent and underfed class, their physical development has been arrested and their bodies stunted. . . . Their unequal intelligence has nothing to do with their capacity for intelligence. Intelligence consists in that capacity together with the supply of information for it to expend itself upon. We see, therefore, that both kinds of inferiority of the lower classes are extraneous and artificial, not inherent and natural.[13]

And again in this same connection, showing the intimate relation of classes to improvement, he says that what we need is not more ability, but more opportunity, and he estimates that if the opportunity could be made for existing ability by the abolition of social classes, the increase in the efficiency of mankind would be at least a hundredfold.

It is hardly conceivable that the breeding of the race-horse type of man will accomplish such a multiplication. We have ability enough; we only need to pry loose what we have.

Race prejudice belongs in the same category as social classes. The existence of a race is primarily caused by accidental signs which serve for identification plus the prevailing attitude towards the people bearing the signs. As Professor Ross says:

[13] Publications of the American Sociological Society, pp. 7, 8.

"Race" is the cheap explanation tyros offer for any collective trait that they are too stupid or too lazy to trace to its origin in the physical environment, the social environment or historical conditions.[14]

In this discussion I would like to substitute "heredity" for "race" and let the quotation read:

"Heredity" is the cheap explanation tyros offer for any collective trait that they are too stupid or too lazy to trace to its origin in the physical environment, the social environment or historical conditions.

When in a Battle Creek restaurant I saw the sign "Colored Patronage not Desired," my sympathy for the Negro enabled me to feel something as he feels, and I can assure you that the depressing force of a public opinion that approves of such discrimination is more influential on the race expression than a very large variation in the germ plasm. W. E. B. DuBois has described this form from the inside in his "Souls of Black Folk" where he says:

They must perpetually discuss the Negro problem, must live, move, have their being in it, and interpret all else in its light or darkness. From the double life that every American Negro must live as a Negro and as an American, as swept on by the current of the twentieth century while struggling in the eddies of the fifteenth—from this must arise a powerful self-consciousness and a moral hesitancy which is almost fatal to self-confidence. . . . To-day the young Negro of the South who would succeed can not be frank and outspoken, but rather he is daily tempted to be silent and wary, politic and sly. . . . His real thoughts, his real aspirations must be guarded in whispers; he must not criticize, he must not complain. Patience and adroitness must, in these growing black youth, replace impulse, manliness and courage. . . . At the same time, through books and periodicals, discussions and lectures he is intellectually awakened. In the conflict, some sink, some rise."[15]

When we remember that more than ten per cent. of the population of the United States belong to this class, we can feel that human progress can not proceed without limit until we have modified our race mores. The sad thing about it is the popular view that the race question is to be explained on biological grounds, and that any race except that to which we have been born is on a lower stage of evolution. We condemn them without trial. Wherever there is white contact with Indians the whole attitude is permeated with the idea that there is no good Indian but a dead one, and their efforts to change their conditions always comes face to face with this prejudice. Much of our immigrant problem is of the same sort. We condemn them in toto, as the brigands of Calabria were condemned in the quotation given. Lord Byron expressed the force of other men's opinion when he said:

I made men think I was what I was not, and I became what they thought me.

We can not escape the great and unjustified discouragement that will come to those we suspect do not belong to the race-horse type. The door of hope is closed to them, while the race horses can not fail to get

[14] "Social Psychology," p. 3.

[15] "Souls of Black Folk," p. 203, McClurg, 1903.

a self-satisfied snobbishness that will make the discouraged plow horse stop in the middle of the furrow. In the same way, registered human pedigrees will inhibit the common stock from making its contribution.

The eugenists have a good deal to say about immigrants. Among the Polish immigrants in America we have a great disproportion of criminals. In the Cook County jail in Chicago they are altogether out of proportion to any other nationality, and the same thing is true in the Detroit House of Correction. The Bohemians, who belong to the same race stock and live in adjoining territory in Europe, have very few criminals, and in Austria there are fourteen cases of litigation among Poles to one among Bohemians. The Polish immigrants are 31.6 per cent. illiterate, and the Bohemians, 3 per cent. The Poles are probably the most devoted to the church and the Bohemians the most rabid free-thinkers of all our immigrants. The social problems arising from these facts have nothing whatever to do with biological inheritance.

Now let us consider the classic example of bad heredity, the Jukes family. Almost everything that is said about the Negro can also be said about them. They lived in New York in the nineteenth century, but they were not a part of it. They were socially ostracized, and built up mores among themselves that had no part in the current civilization. It is barely possible that they averaged mentally inferior to their more socialized neighbors, but the sociologist does not need the inheritance of base characteristics to explain their criminality, prostitution and poverty.

If eugenics succeeds in establishing in the popular mind the tremendous social value of heredity that it is trying to establish, it will overthrow a mass of valuable work of the last decade which has been pointing the way to a fundamental solution of many of our social problems. What if certain people do stand higher on the Binet tests than others; it is yet to be proved that that indicates elemental social value. Psycho-physical parallelism may prevail, but that does not necessarily include psycho-physico-social parallelism.

The position of women has been created in much the same way as races and classes. Alfred Russel Wallace in his last book, "Social Environment and Moral Progress," puts the cart in this eugenic matter where it belongs. He says that when social justice shall have been established and women are free to choose their mates without the artificial conditions that now prevail, then natural selection will take care of itself. I myself am convinced that as a move for race improvement, the equal suffrage of women, with the eventual consequent assumption of intellectual and moral responsibility and economic independence, would be infinitely more valuable than all the eugenic laboratories in the world.

We should use all the forces of science in dealing with pathological conditions, but an attempt at artificial selection of mental and moral characteristics is aiming in the wrong direction.

# THE RACIAL ORIGIN OF SUCCESSFUL AMERICANS

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THE New York World Almanac and Encyclopedia for 1914 gives a table showing the commonest surnames at the present time in England and Wales, Scotland and Ireland, arranged in the order of their frequency, according to a compilation made by the London *Pall Mall Gazette,* also the fifty commonest names in the cities of New York, Chicago, Philadelphia and Boston specially compiled for the World Almanac. A person's last name is not always an indication of race or nationality, but the following names which are here arranged in their order of frequency as they occur in England and Wales certainly have a thoroughly English sound. Smith, Jones, Williams, Taylor, Davies, Brown, Thomas, Evans, Roberts, Johnson, Wilson, Robinson, Wright, Wood, Thompson, Hall, Green, Walker, Hughes, Edwards, Lewis, White, Turner, Jackson, Hill, Harris, Clark, Cooper, Harrison, Ward, Martin, Davis, Baker, Morris, James, King, Morgan, Allen, Moore, Parker, Clark, Cook, Price, Phillips, Shaw, Bennett, Lee, Watson, Griffiths, Carter.

In contrast to this list, the English-sounding names sink to perhaps less then ten per cent. in Ireland. Probably a large proportion of these Anglo-Saxon names belong to the Protestant Irish of Ulster county. The order of frequency for Ireland as a whole is Murphy, Kelly, Sullivan, Walsh, Smith, O'Brien, Bryne, Byrne, Connor, O'Neill, Reilly, Doyle, McCarthy, Gallagher, Doherty, Kennedy, Lynch, Murray, Quinn, Moore, McLaughlin, Carroll, Connolly, Daly, Connell, Wilson, Dunne, Brennan, Burke, Collins, Campbell, Clarke, Johnson, Hughes, Farrell, Fitzgerald, Brown, Martin, Maguire, Nolan, Flynn, Thompson, Callaghan, O'Donnell, Duffy, Mahony, Boyle, Healy, Shea, White. It seems that there are only about nine names of English origin out of these fifty and with the exception of Smith none are high in the list.

In New York City, Chicago, Philadelphia and Boston, the Irish, German, Scandinavian and Jewish elements are recognizable in Murphy, Kelly, Cohen, Levy, Cohn, etc. Immigration has been going on for a number of years, and we may ask to what extent these more recently arrived races have risen to positions of national importance or distinguished themselves in professional life. The compilation "Who's Who in America" endeavors to include, if not the best, at least "the best-known men and women of the United States." The standards of admission divide the eligibles into two classes (1) "those who are

Common Names in American Cities and Number Bearing the Name in "Who's Who in America," 1912–13.

| New York City | | Chicago | | Philadelphia | | Boston | |
|---|---|---|---|---|---|---|---|
| Smith | 27 | Johnson | 4 | Smith | 7 | Smith | 8 |
| Brown | 13 | Smith | 7 | Miller | 4 | Sullivan | 1 |
| Miller | 16 | Anderson | 2 | Brown | 4 | Murphy | 1 |
| Murphy | 5 | Miller | 6 | Jones | 6 | Brown | 11 |
| Meyer | 3 | Brown | 6 | Johnson | 5 | Johnson | 3 |
| Johnson | 9 | Peterson | 0 | Wilson | 6 | Clark | 3 |
| Kelly | 4 | Jones | 2 | Kelly | 0 | O'Brien | 1 |
| Cohen | 1 | Williams | 3 | Williams | 4 | McCarthy | 0 |
| Levy | 1 | Wilson | 6 | Taylor | 5 | White | 2 |
| Williams | 13 | Thompson | 4 | Davis | 3 | Davis | 0 |
| Jones | 8 | Olson | 0 | Moore | 3 | McDonald | 0 |
| Murry | 2 | Davis | 4 | Clark | 2 | Williams | 6 |
| Wilson | 7 | Ryan | 0 | Murphy | 1 | Jones | 1 |
| Clark | 9 | Clark | 2 | Thompson | 1 | Kelly | 0 |
| Sullivan | 2 | White | 2 | Dougherty | 0 | Hall | 3 |
| Martin | 8 | Kelly | 2 | Young | 2 | Taylor | 2 |
| White | 13 | Martin | 2 | White | 6 | Doherty | 0 |
| Davis | 7 | Moore | 5 | Martin | 1 | Wilson | 1 |
| O'Brien | 1 | Schmidt | 0 | Thomas | 1 | Kelly | 0 |
| Ryan | 3 | Sullivan | 2 | Campbell | 1 | Donovan | 0 |
| Moore | 5 | Meyer | 2 | Gallagher | 0 | Murray | 1 |
| Schmidt | 0 | Murphy | 1 | Robinson | 1 | Collins | 0 |
| Taylor | 9 | O'Brien | 0 | Myers | 0 | Robinson | 1 |
| Muller | 1 | Hansen | 0 | Scott | 2 | Moore | 1 |
| Thompson | 7 | Larsen | 0 | Anderson | 0 | Anderson | 2 |
| Anderson | 4 | Taylor | 2 | McLaughlin | 0 | Allen | 5 |
| Walsh | 3 | Walsh | 0 | Allen | 0 | Thompson | 2 |
| Harris | 6 | Young | 3 | Green | 1 | Hill | 3 |
| Reilly | 0 | Campbell | 1 | Fisher | 2 | Ryan | 0 |
| Campbell | 1 | Lewis | 2 | Walker | 1 | Miller | 0 |
| O'Connor | 1 | Mueller | 0 | Morris | 4 | McLaughlin | 0 |
| King | 2 | Baker | 5 | Stewart | 1 | Walsh | 0 |
| Lynch | 3 | Adams | 3 | Wright | 1 | Mahoney | 0 |
| McCarthy | 0 | McCarthy | 0 | Mitchell | 3 | Fitzgerald | 1 |
| Schneider | 1 | Hall | 6 | Murray | 1 | Young | 0 |
| Lewis | 9 | Jackson | 2 | Hughes | 1 | Parer | 2 |
| Ward | 7 | O'Connor | 0 | Lewis | 3 | Lynch | 0 |
| Young | 6 | Hill | 4 | Fox | 2 | Campbell | 2 |
| Robinson | 5 | Burke | 1 | O'Brien | 0 | Martin | 0 |
| Hall | 13 | Allen | 1 | King | 0 | Rogers | 2 |
| Brady | 3 | Olsen | 0 | Evans | 0 | Baker | 1 |
| Burke | 2 | Hoffman | 0 | Roberts | 4 | Foley | 0 |
| Morris | 5 | Green | 1 | Jackson | 1 | Wood | 1 |
| Collins | 3 | Murray | 0 | Harris | 1 | Stevens | 1 |
| Jackson | 7 | Lynch | 0 | Collins | 0 | Morse | 5 |
| Carroll | 2 | Becker | 0 | Snyder | 1 | Crowley | 0 |
| Allen | 13 | Peterson | 0 | Kennedy | 0 | Lewis | 1 |
| Hughes | 0 | Ward | 2 | Wood | 4 | Barry | 0 |
| Klein | 2 | Morris | 2 | Hall | 0 | Burke | 0 |
| Cohn | 2 | Schneider | 0 | Burns | 0 | Driscoll | 0 |

selected on account of special prominence in creditable lines of effort, making them the subjects of extensive interest, inquiry or discussion in this country; and (2) those who are arbitrarily included on account of official position—civil, military, naval, religious, or educational." The arbitrary class embraces, without regard to notability or prominence in any other respect, the following: all members of congress; all governors of states, territories and island possessions of the United States now in office; all United States judges; all judges of state and territorial courts of highest appellate jurisdiction; members of the cabinet; federal department heads; all officers of the army above the rank of colonel, and all of the navy above the rank of captain; all American ambassadors and ministers plenipotentiary; heads of all the larger universities and colleges; members of the National Academy of Sciences, and of the National Academy of Design; heads of all the leading national societies devoted to educational and scientific aims; bishops and chief ecclesiastics of all the larger religious denominations in the United States; and those who are in like manner chosen because of their official relations and affiliations.

In the tables below I present the lists of the most frequent names in New York, Chicago, Philadelphia and Boston as drawn from the World Almanac for 1914, and opposite each, the number residing in each city who are included in the 1912–1913 edition of "Who's Who in America."

Other names of five or more of the same name in "Who's Who" residing in New York, but not included in the above, are Abbott, Adams, Alexander, Baker, Chapin, Clarke, Cooper, Curtis, Davis, Eaton, Fiske, Foster, Fuller, Gilbert, Greene, Holt, Johnston, Lawrence, Lee, Merrill, Mitchell, Morgan, Morse, Norton, Parsons, Perry, Phelps, Porter, Post, Putnam, Richards, Russell, Scott, Stokes, Thomas, Vanderbilt, Walker, Warren, Wood.

All these with the exception of Scott, which is a characteristic Scottish name, and Vanderbilt, which is Dutch, are characteristically English names. It would seem that the original Dutch element has not maintained itself in general leadership in New York. The English element has. I suspect that much of the concentrated eminence now in New York City is due to migration of New England strains from Connecticut and Massachusetts, which states I have already shown to lead in proportion to their population in all forms of creditable activity, and no matter what be the criterion of distinction.[1]

If these fifty commonest names in New York City are arranged in the order in which they are most common on the other side of the Atlantic, 19 of these names will fall to England and Wales, 8 to Scotland, 15 to Ireland, while 8 are characteristicly German or Jewish.

[1] "Historiometry as an Exact Science," *Science*, April 14, 1911.

The nineteen English furnish 168 in "Who's Who." The 8 Scotch 57, the 15 Irish 37, the 8 German or Jewish furnish only 11. Thus it appears that, while the Irish and Jewish element in New York may control politics and the wholesale and retail trade, they have not often risen to high positions.

In Chicago the German and particularly the Scandinavian elements naturally show themselves in the surnames. Smith is even outdone by Johnson (here probably to a large extent Scandinavian). Anderson beats Miller and Peterson beats Jones, Olson is commoner than Davis and appears again as Olsen. Irish names are fairly common, Jewish names are not. The names not of English origin in the above list furnish 12 distinguished Chicagoans against 80 with characteristically English names. Other names of Chicago people occurring in "Who's Who in America" in blocks of four or more are Webster, Black, Carpenter, Cole, Evans, McCormick, Mathews and Stone. Not a single foreign name occurs frequently. Crediting each common name in Chicago to the European country in which it is most common and leaving out Johnson and Anderson as doubtful cases, the distribution and number in "Who's Who" is as follows: 18 English names furnish 59 distinguished individuals; 7 Scotch 24; 11 Irish 11. The 12 Germans, Jewish, Scandinavian or other common names furnish none!

In Philadelphia (of the 50 commonest names) 32 characteristically English names total 86 distinguished persons, 18 non-English total only 7. Crediting each common name to the "Old Country" in which it is most common, we find the distribution is England and Wales 28 names with 45 in "Who's Who in America." Scotland 11 names with 18; Ireland 9 with 4, and 2 other countries with 1.

For Boston the facts are a little startling. It seems almost unbelievable that the Irish making up more than half the population of the city, many of whom represent the second and third generation (for the Irish began to come to Boston in large numbers as early as 1830), can furnish only about two dozen persons entitled to national recognition.

According to "Who's Who in America" there were no persons in Boston entitled to inclusion, at the beginning of the year 1912 bearing the most common names of McCarthy, Davis, McDonald, Kelly, Doherty, Kelley, Donovan, Collins, Ryan, Miller, McLaughlin, Walsh, Mahoney, Young, Lynch, Martin, Foley, Crowley, Barry, Burke and Driscoll. Four of these names are Anglo-Saxon in origin, 3 are common to both the Scotch and Irish and 14 are essentially Celtic. Among the 50 commonest names in Boston found in "Who's Who," those of Anglo-Saxon origin total 64 distinguished representives, those of Celtic only 5. There should be about the same number of Anglo-Saxon and of Celtic since 20 of these common Boston names are Celtic to 26

Anglo-Saxon and about half the present population is Catholic Irish. Looking at the matter another way and crediting all of each name to that country of origin in which the name occurs most frequently, or highest in the *Pall Mall Gazette* list, we find England and Wales 21 names credited with 55; Scotland 8 names credited with 14; Ireland 21 names credited with 5 distinguished, or more strictly speaking, widely-known Americans now residents of Boston.

It is true that people of non-English origin often change their names, making them more attractive to American ears, a Schneider becomes a Taylor, a Weiss a White, or even a Solomon Levi may become a Sydney Lee. But I do not believe that such changes can have had any appreciable effect on the present investigation and none at all on the conclusions. I do not believe that more than a very small proportion of these persons in "Who's Who in America" who have English names have acquired their names in any other way than by natural descent. For the Boston statistics, I have been able to test this question by personal knowledge of the individuals or from genealogical inquiries. I know of two cases of notable foreigners bearing English names, one a Portuguese and one a Jew; but out of the 851 Bostonians in "Who's Who," I am very sure that not five per cent., probably not one per cent., have English names by change from a foreign one. I have made a special test of the Boston names and find out of 851 persons, that (bearing in mind the possibility of slight further readjustments) they must be classified as 19 Irish, 10 North Irish, 30 various European names and doubtful cases and 786 of true English or Scotch origin.

Thus to summarize: In the 4 leading American cities, New York, Chicago, Philadelphia and Boston, it is safe to say that, at the present time, those of English and Scotch ancestry are distinctly in possession of the leading positions at least from the standpoint of being widely known, and that, in proportion to their number, the Anglo-Saxons are from 3 to 10 times as likely as are the other races to achieve positions of national distinction.[2]

The cities contain most of the foreign elements. The cities are also the concentration points for most types of ability. They are also the breeding grounds of future leaders.[3] Therefore this study of the

[2] It is not possible to express this ratio accurately without a great deal of labor. Since the commonest names of all, Smith, Brown, Miller, Johnson, Sullivan, etc., are, on the whole, more English than foreign, all names can not be given the same weight. It would be necessary to go through the directories, count the names, and thus get the separate weights for each name.

[3] See F. A. Woods, "City Boys *versus* Country Boys," *Science,* April 9, 1909; and "The Birthplaces of Leading Americans, and the Question of Heredity." Mr. Spillman's side of the case should also be read, though his statistics seem to me to be meager. Galton for English scientists and Odin for French *littérateurs* have both found city-birth predominant.

4 cities ought to suffice to throw light on a number of important questions.

The truth of the matter is that all the stocks that have come into America in recent years since 1830 have been very inferior to those already here in the seventeenth and eighteenth centuries; and in general they have been getting worse and worse. There have been a few notable exceptions, but broadly speaking all our very capable men of the present day have been engendered from the Anglo-Saxon element already here before the beginning of the nineteenth century. We sometimes read magazines and newspaper articles about the Irish in America, the Germans in America, the French in America, the Jews in America, describing the achievements of distinguished foreigners who have risen to high esteem and publishing portraits of the same. It is because they are relatively few that it is possible to make a magazine article out of the material. Who ever saw a similar article on the English in America? The statistically true can be exciting only to the scientifically inclined.

We have heard a great deal about the Melting-Pot, but no one as far as I know has brought forward any proof that there is a Melting-Pot in true biological sense, *i. e.*, that there is any genuine mingling of blood sufficient to overcome the natural tendency that all species and varieties have to grow apart and become more dissimilar in course of time. If there had been a thorough mingling of the races in this country, there would have already been a decline in natural ability, but the tendency of like to mate with like, the natural tendency of the most successful to mate among themselves, works in the opposite direction. The real strength of a country is so dependent on the qualities of its leaders that it behooves patriots, sociologists and philosophers to take all these questions into account and consider more carefully the genesis and significance of that small fraction of one per cent. which represents the intellectual crust.

# DARWIN AND WALLACE ON SEXUAL SELECTION AND WARNING COLORATION

By Professor F. H. PIKE
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IN looking over the life of Wallace recently, my attention was again drawn to the differences in opinion existing between Darwin and himself, with reference to sexual selection. Wallace objected to Darwin's assumption that a bright or peculiar color or a peculiar note or call would attract the attention of other individuals of the same species but of the opposite sex, on the ground that such a process could not become operative in forms which did not have sufficient intelligence to discriminate, and hence could not explain the occurrence of such characters in the lower forms. And if the plaint of the eugenists be accepted at its face value, the degree of intelligence even in the human subject to-day is not sufficient to insure discrimination in choosing a mate.

The development of our knowledge of animal behavior, on the one hand, and the advances in our knowledge of the nervous system, on the other, appear to me to make possible a reconsideration of the matter from the point of view of one or the other of these two lines of work at the present time. It must not be supposed that the approach from this angle will settle the question quite independently of other considerations, but such a method of approach may adduce some independent probability of the soundness or unsoundness of Darwin's point of view.

In the first place, sexual selection with reference to color of coat or plumage or of song is dependent upon the existence of a particular group of sense organs capable of perceiving objects at a distance—the distance receptors as Sherrington[1] calls them. These are the eye and the ear and the olfactory organ. The perception of color and voice depends therefore upon the development of the eye and the ear. Sexual selection with reference to these two characters can not be operative, therefore, in forms not able to see or hear.

It is evident that any other process of selection that is dependent upon coloration, even including protective coloration under certain conditions, must be considered from the same point of view. We may, therefore, discuss the subjects of colors of flowers as a means of attracting bees, warning coloration, protection by mimicry, and certain phases

[1] Sherrington, "Integrative Action of the Nervous System," New York, 1906.

of protective coloration in connection with sexual selection, since it is clear that the same objection, namely, the need of intelligence, may be urged against the assumption of warning coloration. And warning coloration is effective against some animals with distance receptors, but not necessarily against animals without such sense organs.

Visual and auditory mechanisms make their appearance well down in the animal scale, and hence the possibility of reactions through these mechanisms also arises rather low in the scale. The question then shifts to the central nervous system, and we must inquire whether in any of the lower forms, before the onset of intelligence, reactions to color are possible.

Since the work of Sumner[2] on the change of color pattern in flounders when placed in an aquarium with a certain color pattern in the bottom, we have known that reactions to color do occur under certain conditions. There are, of course, certain limitations to the process, and the mechanism of the response may still require investigation, but the response of the fish to visual impressions is undoubted, and it would be a far cry to postulate intelligence in the process. If a flounder responds to changes in the color pattern of the bottom of an aquarium, it is apparently not a more serious offense to postulate a response to a peculiar color pattern in another flounder. Other observations of the same kind on other animals lead to similar conclusions with regard to response to color. In the terminology of the physiologist, the response is a reflex process, involving an afferent or sensory impulse, the mediation of the central nervous system, and some efferent or outgoing nervous channel to the pigment cells of the skin. The medieval debate as to whether a reflex must always occur through the spinal cord, or even through the palæencephalon[3] is quite beside the point.

Another instance in which the appeal of color or odor is of importance is the attraction of bees and insects generally by flowers. The debate on the color vision of bees is far from closed, but that color plays some rôle will probably be admitted without prolonged argument. Whether bees have a sense of smell may perhaps be an open question, but that flowers attract bees seems clear. Both flower and insect visitor often have developed extraordinary modifications of the primitive type of structures so that neither insect nor flower can get along without the other. The yucca plant and the Pronuba moth constitute a case in point. Often but one species of insect can fertilize a particular flower, and it may happen that an insect can successfully visit but one species of flower. The question is not so much how the insect knows enough to visit that particular flower, but what particular features of the flower appeal to specific sense organs of the insect.

2 Sumner, *Journal of Experimental Zoology*, 1911, X., pp. 409–479.

3 Edinger, *Journal of Comparative Neurology*, 1908, XVIII., pp. 437–457.

In warning coloration or terrifying attitudes, nothing can be warned or terrified which does not see the warning or terrifying individual. The only question that arises is again whether the warned or terrified one must be possessed of sufficient intelligence to think the matter over and decide according to the evidence presented to it by the visual mechanism or whether it merely obeys the first impulse. Wallace himself proposed this theory of warning coloration, and it must stand or fall on purely theoretical grounds along with the theory of sexual selection, postulating, as it does, the same mechanisms in the warned individual that Darwin's hypothesis postulates in the attracted individual. There is, however, more direct observational evidence in favor of warning coloration than there is in favor of sexual selection. Birds, as Wallace showed, are warned by certain colors of butterflies.

Whitman's[4] observations on pigeons show that their responses and reactions are in many cases purely instinctive, being elicited without previous education or experience, and occur only when the group of conditions is right. Instinct, to me, at least, means a definite response to a definite group of afferent impulses. The afferent impulses once set up, the response of the central nervous system is the same under the same conditions. As Whitman expressed it, "organization shapes behavior," a statement directly in line with Hermann's law of specific response to stimulation. And from this statement of Whitman's dates the transition of the discussion of animal behavior in metaphysical terms to its discussion in terms of biological entities. In animal behavior, organization centers largely, though not wholly,[5] around the central nervous system and its associated afferent and efferent channels and sense organs. Internal secretions of various ductless glands of the body, and afferent nervous impulses from certain of these various glands are, of course, to be considered in animal behavior, and all of them have their influence on the instinctive responses of animals at various seasons of the year. Yet all these things are to be considered as a part of the organization of the individual at any one time. And the conviction is slowly growing, in my own mind, at least, that it is not so much a single afferent impulse as it is groups of afferent impulses that determine the reactions of animals. A few illustrations will make this point clearer.

Hunger has been shown to be associated with definitive movements of the stomach in man, and hence with definitive afferent impulses from the stomach.[5a] In the wider sense of the term, hunger is of reflex origin. The feeding reactions of the newly hatched *Necturus* are accurately and certainly elicited when the animal is hungry, as Whitman showed, but

4 Whitman, "Animal Behavior," Marine Biological Lectures, 1898.

5 Pike, *Quarterly Journal of Experimental Physiology*, 1913, VII., pp. 22–26.

5a Cannon, Harvey Lectures for 1911–12, pp. 130–152, Philadelphia.

not when the hunger is satisfied. There has been much debate as to why the animal no longer responds as well to the sight of food held in a certain position after its hunger is satisfied as before. It would seem sufficient to remember that the afferent impulses coming from a full stomach differ greatly from the afferent impulses coming from an empty one; and it is not, in my opinion, necessary to postulate a mysterious psychical change, of obscure origin, in the animal to explain its failure to take food after its hunger is satisfied. While all the external conditions may be the same, the afferent impulses from the stomach, and hence the group of afferent impulses concerned in the feeding response, is changed after hunger is satisfied. Two different groups of impulses, although they may have certain impulses in common, are not necessarily integrated to the same motor response.

The "Geschlechtstrieb" is similarly associated with a particular group of afferent impulses, dependent from their origin, among other things, upon changes in internal secretions, and changes in the circulatory conditions in particular local regions. A review of the various influences operative in exciting sexual desire of higher animals is found in a paper by von Bechterew,[6] and the argument need not be pursued at length here. Sufficient has been said to show that both the feeding and the sexual act have their driving force in particular groups of afferent impulses, some of which are of internal (proprioceptive or interoceptive) origin. The state of hunger or of sexual desire once established, the consummation of either the feeding or the sexual act is dependent upon external conditions which may be more or less fortuitous. The sight of food when the animal is hungry is an incitement to take food. If the sight of a peculiarly colored butterfly warns the bird, we will say, against taking it as food, we have the afferent impulses of internal and of external origin acting in opposition, and it will readily be seen that if the color of the butterfly is to protect it, that color must convey a very strong stimulus to the bird.

In the case of the sexual act, the conditions under which Darwin imagined that pleasing song or beauty of plumage might be operative are somewhat different. The female is ready for the sexual act, and awaits the coming of the male. To the internal stimuli, there may conceivably be added an external group in the nature of a color pattern that attracts her attention or a song that mingles with the mood or more properly, with the group of other afferent impulses, and the addition of these simple elements, not necessarily powerful in themselves, may be just sufficient to turn the balance in the favor of the male possessing them. In the case of warning coloration, the warning color must act as a powerful deterrent agent, but in the case of a bright plumage or a pleasing song, both external and internal stimuli work together.

[6] Bechterew, *Archiv für Physiologie* (Englemann's), 1905, p. 524.

Nor can it be held that warning coloration depends upon the intelligence of the warned individual. Certain mimic butterflies may have only a superficial resemblance to each other, but the resemblance is sufficiently close to save the mimic from attack by the animals which spare the mimicked forms. Birds are not close critics or students of certain types of color patterns. A more critical observer would not be so easily deceived.

These considerations are wholly independent of the origin of mimicry. Conceivably, there have been cases arising in nature in which one species has developed certain characters which render it unfit for food; and another species, which may develop a color pattern similar to that of the noxious form, has been spared because of this resemblance. But all cases of supposed mimicry are not necessarily of this sort. As Eigenmann[7] has shown, many cases which might, under other conditions, have passed for mimicry are really cases of convergent or parallel evolution, the similarities arising from similar responses of different organisms to the same or similar features of the environment. Indeed, Eigenmann's position seems especially strong, since he is able to supplant the hypothesis of mimicry, wherever it is weak, by the more general theory of natural selection. But the essential point to be kept in mind in this connection is that, no matter how the resemblances may have arisen, if mimicry protects at all, the mimic escapes because of the lack of a keenly critical faculty in the pursuer.

An animal of a low grade of intelligence is more apt to show uniformity of deportment than an animal of a higher grade. The frog has never rivaled either the serpent's or the owl's reputation, possibly undeserved, for wisdom, but it reacts to a red rag with avidity. A really intelligent animal would not be so easily humbugged. A contraption of feathers, gay colors and steel wire will lure a trout from his pool, often to his sorrow, but the deception in the hands of competent deceivers proceeds from year to year. Any skillful angler will verify the statement that it is the trifling things which are of importance in the pursuit of fish. The catfish is more prosaic and demands more of the reality in the form of worms, not being satisfied with the mere semblance of food.

The arguments which apply to warning coloration apply equally well to sexual selection, and it is clear from what has been said that neither sexual selection nor warning coloration require any great amount of intelligence on the part of the warned individuals or the pleased ones. Indeed, it is conceivable that both processes might act more strongly in animals which were not too intelligent. In man, financial, social and family considerations often outweigh the more natural considerations.

[7] Eigenmann, *Annals of the Carnegie Museum,* 1909–10, VI., pp. 4–54, and later papers.

Arguments of this kind can not, of course, lead to a definite settlement of the question of the potency of sexual selection, but they appear to increase the probability that sexual selection may be a reality, and a more potent agent in evolution than we have realized or been inclined to admit. Many peculiar characters have a function that is at present unknown, and many of these unknowns have been supposed to act as factors in sexual selection. More accurate observation has, however, shown their true use in the animal's activities. The horns of the *Orocytes rhinoceros,* recently described by Doane[8] afford an example of a character, once supposed to be effective in sexual selection, which has proved to be of direct use to the animal in getting its food, and hence, an agent in natural selection. Undoubtedly, further studies of animals and plants in their natural environment will lead to still further instances in which characters apparently useless, so far as their relation to getting food or resisting enemies goes, will prove to have some direct use in the life of the animal or plant. Even at present, characters supposed to be active through sexual selection alone should be scrutinized with some care before their case is admitted to serious consideration.

The view that the secondary sexual characters are the expression of internal metabolic changes, internal secretions, and the like, does not exclude a selective value. Darwin did not explain the origin of such variations, but supposed that they might be of selective value, and if secondary sexual characters are related to the activity of organs of internal secretion, such an occurrence need not disturb us. Physiologists generally regard all an organism's responses as due to an interaction of internal and external factors, and some such similar relationship is probably at the bottom of orthogenesis. As I hope to point out in a later paper, there is much evidence of a chemical nature in favor of orthogenesis.

It is true that external characters or purely morphological characters such as muscles and bones have, heretofore, formed the greater part of the subject matter of discussions on evolution. But the idea of the potency of internal functional factors in evolution has crept in, and Gaskell has pointed out that two general kinds of mechanisms of internal coordination—the nervous and the chemical—have been concerned in evolution. Both kinds of mechanisms are of selective value. Regarding lactation as a secondary sexual character, great changes in such a character, dependent partly upon morphological, but largely upon chemical organization, have been brought about in the various breeds of dairy cattle by artificial selection. And in this domain of the heredity of chemical characteristics lies a whole field of experiment on characters susceptible of accurate quantitative measurement as yet barely touched by the hand of the Mendelian.

[8] *Science,* 1913, N. S., XXXVIII., p. 883.

It is a truth that loses none of its force by repetition that in laboratory observation of animals, the laboratory conditions do not always accurately represent the conditions in nature, and that the deportment of an animal in the laboratory may not be exactly the same as its deportment in nature. The failure of some relatively high animals to breed in captivity is a case in point, and this again calls attention to the importance of a group of afferent impulses rather than a single impulse in determining the response of animals. Some subtle influence of the natural environment is lacking in the conditions obtaining in captivity, and the normal deportment of the animals is modified in at least one important detail. Other animals have a nervous system of sufficient plasticity to adjust themselves to the changed conditions of the laboratory or zoological garden. But the laboratory experimenter is now, and will be for some time to come, dependent upon the data of close and accurate observers of animal life in the field for his basis of comparison. And until the laboratory worker is certain that the deportment observed in the laboratory corresponds to that in nature, his analysis is not biologically accurate.

It is probably true, as Professor Cockerell[9] suggests, that no man will ever be able accurately to tell the complete story of Wallace's life work, even on its biological side alone, using the word in its widest sense. It is an evidence of the genius of Darwin and of Wallace that each was able to get such a fundamental grasp of the phenomena of nature as to afford problems for workers in other lines apparently far removed from their own. The experimental physiologist has had relatively little to say in regard to evolution as yet, and is perhaps in no position to settle dogmatically any particular problem now. But physiology has a direct contribution of interest to the worker in certain phases of a much wider problem. Specialties multiply, new and confusing terminologies develop, and the point of view ever tends to become narrow. Biologists pursuing one specialty have more and more difficulty in communicating to biologists in other lines of work, the particular results in their own. And biologists are almost unintelligible to workers in physics and chemistry. Yet science is a unit, and there can be no lasting truth developed in one field unless it is in accord with truth in every other field. The task of finding out what other workers have to offer us is a huge and even insuperable one under present conditions. Some hope of relief may be held out when the biologists get some of their great generalizations reduced to simpler form, and consequently intelligible to the scientific multitude. At present, the theory of evolution seems to be the most promising common meeting place to which biologists in all lines of work may bring their contributions for the judgment and criticism of their brother workers.

[9] *Science*, 1913, N. S., XXXVIII., p. 871.

> In fact, it seems as if Darwin and Wallace, Nägeli, Haeckel, Dohrn, Weismann, De Vries and a host of other investigators, had grappled with an all-embracing problem—a problem of problems that must engage the best energies of all the sciences for centuries yet to come.[10]

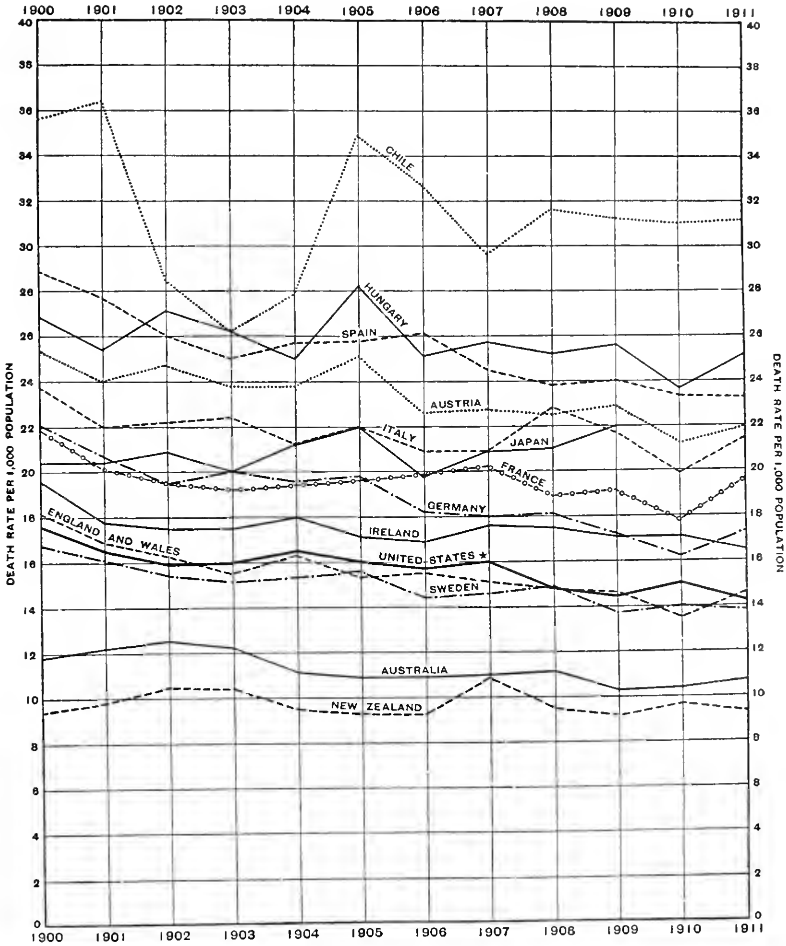
It is a striking evidence of the slight degree to which our subjects have been developed that we are so often blind to the general implications of our work, and the need for help from every conceivable quarter was never greater than now. The opportunity to acknowledge the influence of the great group of English biologists—Darwin, Huxley and Wallace, who showed that evolution of some kind and through some agency was a fact—upon my own line of work in an apparently distantly related field is a particularly grateful one. And it is more in the hope of directing attention to the tremendous breadth of the problem than of emphasizing any particular views of my own that this article is written. And if what I say may direct the attention of any other worker, in an apparently far removed and exceedingly specialized line, to what he may have to offer on the great problem of evolution in general, it will be well.

[10] Whitman, *Bulletin of the Wisconsin Natural History Society,* New Series, 1907, V., p. 6.

# THE PROGRESS OF SCIENCE

## *MORTALITY STATISTICS OF THE UNITED STATES*

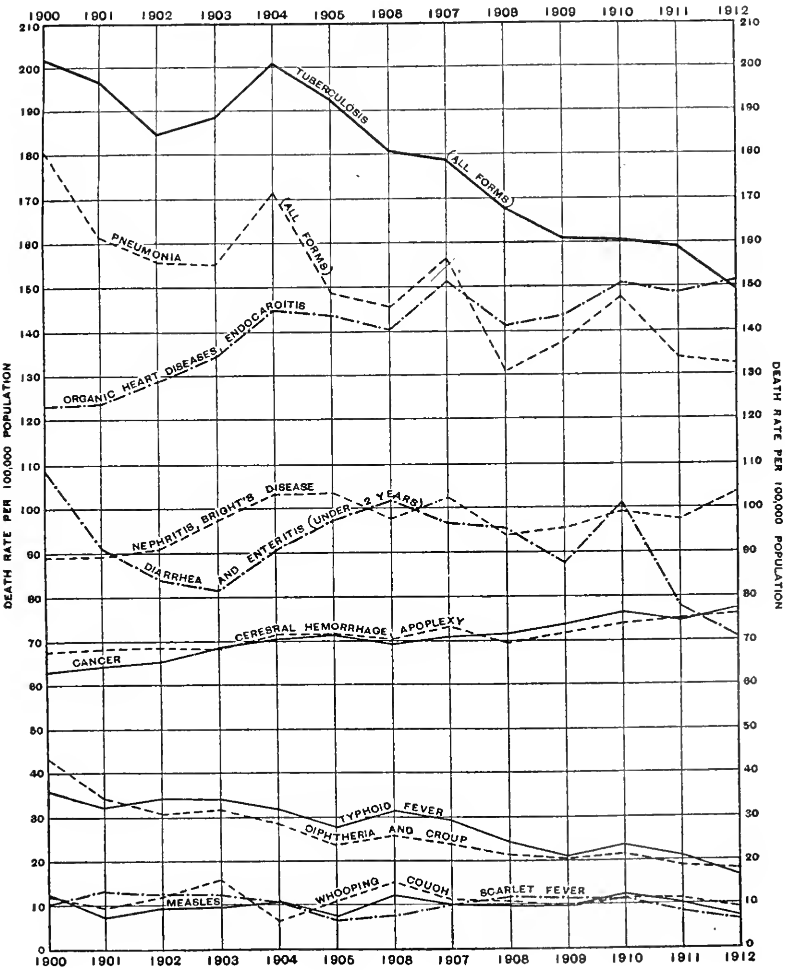
THE Bureau of the Census has published its thirteenth annual report on mortality statistics, this report for 1912 following closely on that for 1911. The death rate in the registration area, which now includes about two thirds of the population, fell from 14.2 for each thousand of the population in 1911 to 13.9 in 1912. There are always fluctuations in the death rate due to weather conditions, epidemics, etc., but, as shown in the chart taken from the report, the death rate has steadily decreased from 17.6 in 1900. This means that in so short a period the saving of human lives in this country amounts to about 350,000 a year, a statement which it is difficult to appreciate at its true magnitude. In 1880 the death rate was 19.8. If we



Benjamin Osgood Peirce.
Late Hollis Professor of Mathematics and Natural Philosophy in Harvard University, distinguished for his contributions to mathematical physics.

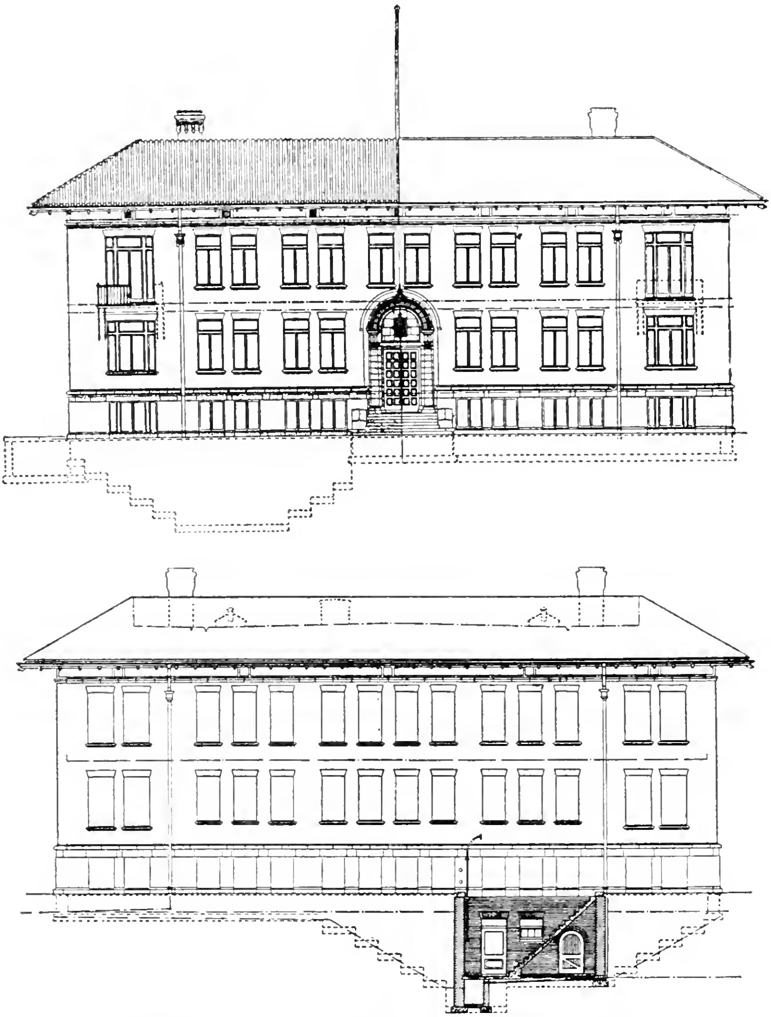
put a merely commercial valuation on the lives saved, it amounts to a billion dollars a year. It would surely be reasonable to spend the amount thus saved by better living conditions, improved hygiene and more efficient medical service to promote further advances in the same direction.

The death rate has declined in all the great nations, with the possible exception of Russia and Japan. Thus since 1886 the decrease in England has been about 6, in Germany about 9, in France about 3. These great differences for different nations are in large measure due to the age constitution of their populations. Thus England has doubled its population by natural increase in sixty years and Prussia in fifty years, but now the birth rate is rapidly declining. There is thus in their populations a small proportion of old people and a decreasing proportion of young children, which in large measure explains why the death rate is lower than in France where the population has been nearly stationary and there are nearly twice as many old people. The death rate for New York City in 1912 was 14.5, and for the entire state 15, but this does not mean that conditions are more favorable to health and to long

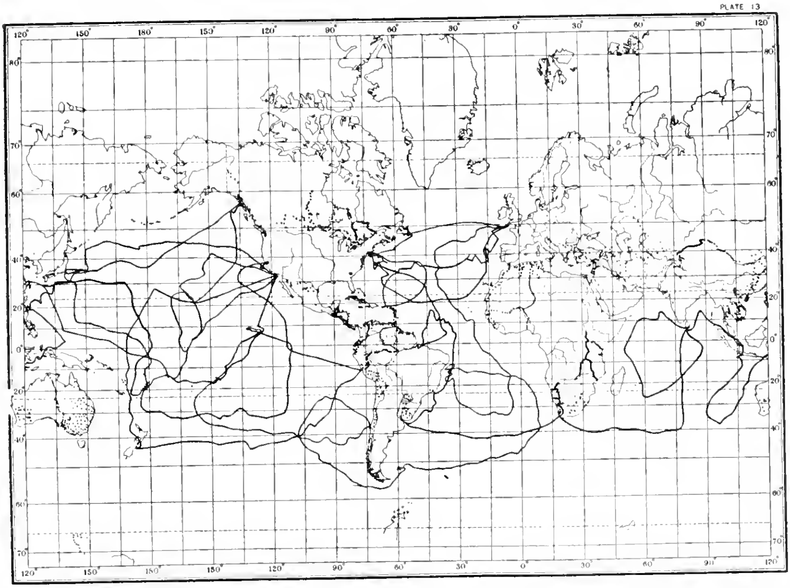


life in the city than in the country. The death rate in New York City is low because owing to emigration from abroad and the influx of young people from the country an unusually large percentage of the population is at the age when deaths are few.

In order to compare populations of different age and sex constitutions it is necessary to recalculate the rates for a standard population. Our Census Bureau has rather oddly chosen the population of England as the permanent basis of standardized rates. This population is about as abnormal as could be found, it having resulted from a large birth rate rapidly declining and a large emigration. For example, there is an excess of 1,200,000 women. There should be an international convention to fix a standard population, either a weighted average of the populations of the countries having adequate statistics, or an ideal population resulting,



FRONT AND REAR VIEWS OF THE BUILDING FOR THE DEPARTMENT OF TERRESTRIAL MAGNETISM.




THE MAGNETIC WORK OF THE DEPARTMENT OF TERRESTRIAL MAGNETISM, showing the ocean cruises and land stations.

say, from a birth rate of 20 and a death rate of 15.

The curves that are reproduced showing the death rates for each hundred thousand of the population from certain diseases can not be very accurate, as it is in many cases impossible to assign a single cause for death, and the returns of physicians are incorrect in a large percentage, perhaps in a majority, of cases. Still the curves are instructive, more especially in showing the decrease in certain contagious and preventable diseases, and the increase in certain organic diseases. In the short period of eleven years the rate for tuberculosis has decreased from 202 to 149; for infant diarrhœa, from 109 to 70; for typhoid fever, from 36 to 16; for diphtheria, from 43 to 18. On the other hand, the rate for heart disease has increased from 123 to 151; for apoplexy, from 67 to 75; for Bright's disease from 89 to 103, and for cancer, from 63 to 77.

It is evident that people must die some time and somehow; if they escape from the diseases prevalent in the earlier years of life, they must die from those of later life. It is also the case that the decreases noted are far greater than the increases. Still it is true that the decrease in the death rate is in the earlier age groups, while there has been an increase after the age of fifty-five. This has been attributed to the fact that the conditions of modern life are unfavorable to people of middle age. The fact seems to be, however, that the diseases from which people are likely to die in middle and old age are not to a considerable degree preventable, and the very fact that the lives of millions of infants and young people who were below the average in constitutional strength have been saved must lead to a higher death rate when they become more advanced in years.

## *THE WORK IN TERRESTRIAL MAGNETISM OF THE CARNEGIE INSTITUTION*

AMONG the large mass of important scientific research conducted under the auspices of the Carnegie Institution of Washington and described in the annual report of the president, that in terrestrial magnetism deserves special notice this year, in view of the fact that it is being provided with a permanent laboratory. As the director of the department, Dr. L. A. Bauer, points out, work on terrestrial magnetism and atmospheric electricity has been mainly observational. Magnetic and electric surveys have been extended to nearly all parts of the earth, and observatories have been conducted at a number of points at which are registered the variations to which the magnetic and electrical elements are subject with time and with varying planetary and solar conditions. But hitherto there has been no laboratory for the investigation of these phenomena of terrestrial and cosmical physics similar to the laboratories of astrophysics, to which are due such remarkable progress in that science.

The Carnegie Institution, which in the establishment of the solar observatory at Mount Wilson has contributed very greatly to the advance of astrophysics, has now undertaken to construct for its work in terrestrial magnetism the building of which views are here reproduced. It is being erected on a tract of land of about seven acres in Washington, about a mile north of the Bureau of Standards and the Geophysical Laboratory. The grounds are sufficiently removed from disturbing influences, so that the testing and comparisons of magnetic instruments and work in atmospheric electricity may be successfully carried on. The building, which is now nearly completed, consists of a basement, two stories, and an observation-roof, the size being 51 by 102 feet.

In addition to the work done in Washington, magnetic surveys of land areas have been made in various parts of the earth, including the Sahara Desert, Canada, west of Hudson Bay, northeastern South America and Australia. The accompanying map shows how extensive have been these surveys, including the two cruises of the non-magnetic ship *Carnegie,* which has now traversed a distance of about one hundred thousand miles, preceded by cruises of some sixty thousand miles by the chartered ship *Galilee.*

The Carnegie Institution has, in addition to this new laboratory and its administration building in Washington, erected buildings for its departments, each with their equipment, valued as follows: The Solar Observatory on Mount Wilson and at Pasadena, $754,000; the Geophysical Laboratory in Washington, $198,000; the Desert Laboratory at Tucson, Arizona, $48,000; the department of Experimental Evolution at Cold Spring Harbor, Long Island, $70,000; the Nutrition Laboratory, adjacent to the Harvard Medical School in Boston, $129,000, and the Department of Marine Biology at the Tortugas, $47,000. This last laboratory it is now proposed to remove to Jamaica.

## *SCIENTIFIC ITEMS*

We record with regret the death of Dr. Robert Kennedy Duncan, director of the Mellon Institute for Industrial Research in the University of Pittsburgh; of Professor William Whitman Bailey, professor emeritus of botany at Brown University; of Dr. Roswell Park, professor of surgery at the University of Buffalo; of Edward Singleton Holden, librarian of the U. S. Military Academy, formerly director of the Lick Observatory; of Dr. Albert Gunther, late keeper of zoology in the British Museum, and of Sir John Murray, the distinguished oceanographer.

Sir Francis Darwin delivered the first Galton anniversary lecture on February 16 in London. The subject of the lecture was Francis Galton—Professor R. W. Wood, of the Johns Hopkins University, gave in London, on February 27, the first Guthrie lecture of the Physical Society, his subject being "Radiation of Gas Molecules Excited by Light."

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# THE MEASUREMENT OF ENVIRONIC FACTORS AND THEIR BIOLOGIC EFFECTS[1]

By Dr. D. T. MacDOUGAL
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THE simpler forms of plants in earlier geologic times lived in swamps and along seashores and under the equable conditions furnished did not attain anything beyond a primitive and elementary development. The chief bar to escape from the restricted moist habitats consisted in the fact that the life cycle of the plant included alternating generations in one of which, the sexual generation or gametophyte, reproduction was possible only in the presence of water. Finally, however, the spore which gave rise to this sexual generation began to germinate in place on the other generation and the resulting gametophyte was produced, and remained enclosed in the tissues of the sporophyte as it is among the seed-plants of the present day.

The domination of the sporophyte in this manner vastly increased the possibilities of evolutionary development, and when this plastic self-contained type of plant began to move out over the broad spaces of the world, all the ranges of temperature afforded by the earth's surface, as well as of moisture, illumination, concentration of the solutions in the soils, alkalinity, etc., were encountered to which to-day the manifold types of plants stand in a delicate adjustment.

Water was the chief determining factor when the vegetal organism was in a separated-generation stage, and it continued to be the most potent agency in evolution and differentiation as the new combined individual moved away from the swamps and shores to the occupation of the drier slopes of valleys and mountains and finally into the most arid of deserts.

[1] Formal abstract of lecture given before the trustees of the Carnegie Institution of Washington, in connection with the Annual Meeting, December 1, 1913.

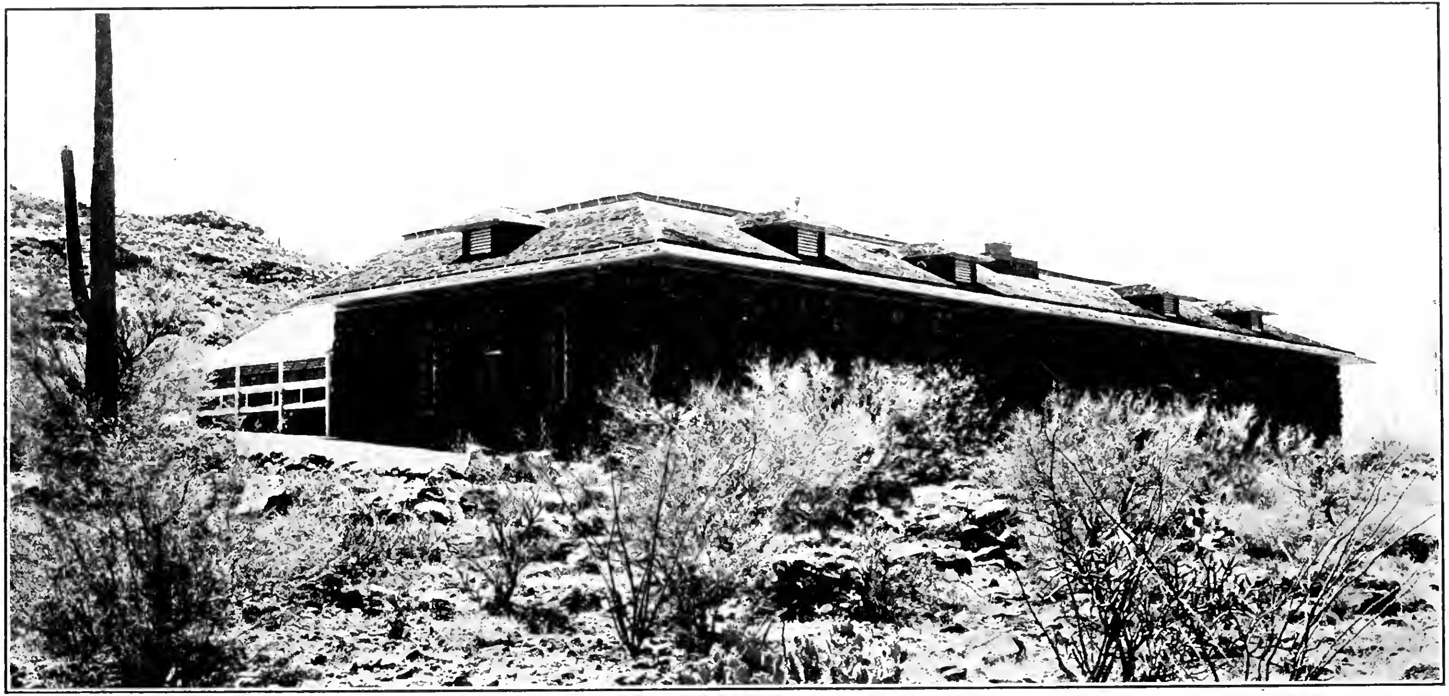


Fig. 1. The Desert Laboratory, Tucson, Arizona.

The relation of plants, and of all organisms to water, is, therefore, a fundamental one, and it is to the determination of these and other important environic relations that a large share of the attention of the department of botanical research is directed. If this conception has been properly formulated you will be prepared to receive without surprise the statement that the Desert Laboratory as the principal instrument of research of this department was not established primarily for the purpose of making studies upon desert vegetation as such.

There is no adequate foundation for a science devoted to the organisms which live in arid regions. There is no more a desert botanical science than there is a mountain astronomy. The physicist seeks and selects a place for the operation of his instruments in which observations and experiments may be carried on to the best advantage. The biologist takes one of his laboratories to the seashore and another to the desert, because here in these places organisms carry on the various processes in tissues of diverse structure and at different rates, and extended facilities for experimentation and widened angles of observation are made possible.

If to these statements as to the purpose and general scope of our researches, a few words be added as to the view-point taken as to the constitution of living matter itself, we may then profitably proceed to a discussion of the main thesis of the present paper.

Protoplasm is characterized by the fact that it includes an enormous number of compounds of carbon, oxygen and hydrogen, which sustain comparatively simple (chemical) structural relations to each other and most of which are highly unstable. These two features make possible variety and complexity in the mechanical structure and composition of the tissues of plants and animals, give opportunity for the occurrence of a multiplicity of chemical transformations in metabolism, and render all the functions of the organisms highly modifiable.

Any sense of daze we may experience from a contemplation of the number of things, or combinations in protoplasm, however, is not a logical excuse for going into the haze of vitalistic notions upon which much of the pedagogical practise and speculative writing in biological science of the present time is based. Ten, or ten million, the components of protoplasm act in accordance with a few fundamental physico-chemical laws. Complexity of composition yields in importance to the types of energy transformations displayed, and to the external expression of what are known as the biological activities as they may be modified by the environment.

The plant may be profitably visualized as an upright cylinder of watery gelatine surrounded by a semi-permeable tubular casing. The lower extremity of this cylinder is ramified into roots which are in intimate contact with moist soil-particles, so that the water in the body of

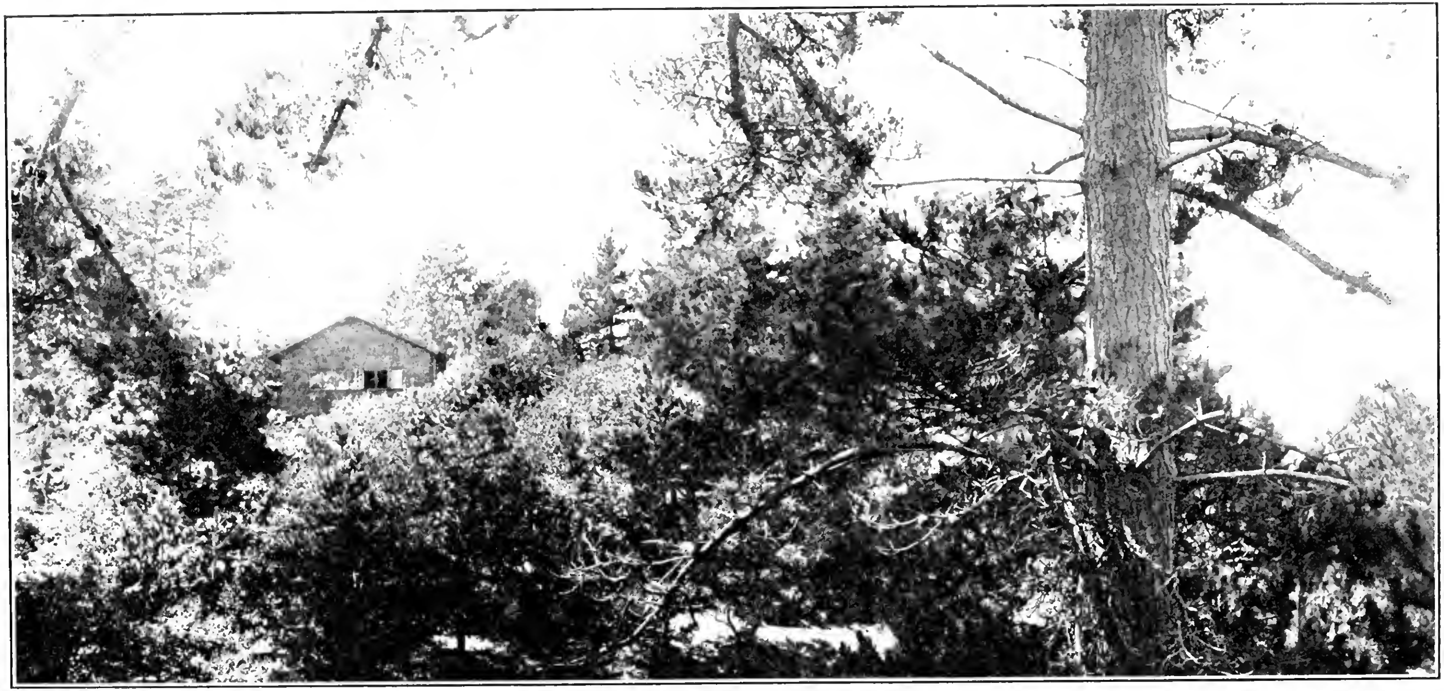
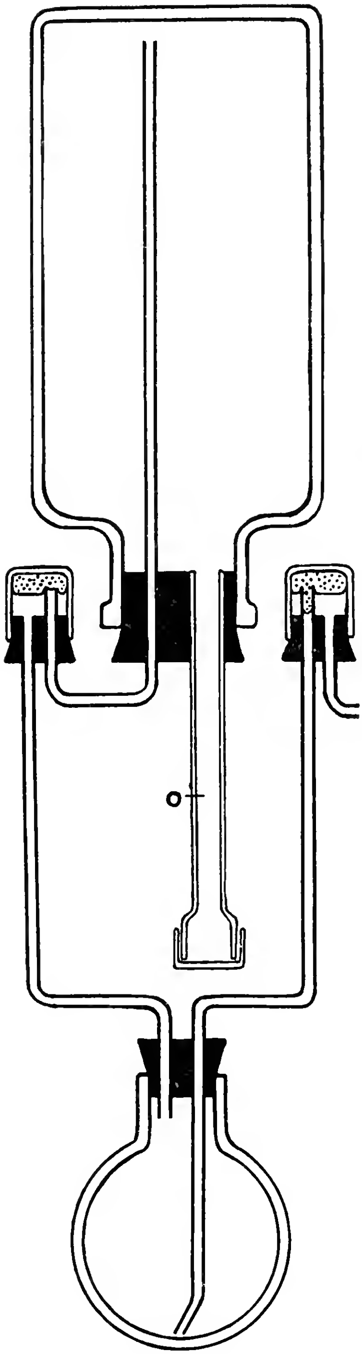


Fig. 2. The Coastal Laboratory, Carmel, California.




the plant is practically continuous with that in the substratum. The absorption of water by the plant, or rather the movement of water from the soil into the plant is influenced by the agencies which affect diffusion, osmosis and adsorption anywhere. In other words, the properties of protoplasm, as a mixture of colloids, cause water to move from the substratum into its body. The further movements of water, such as the ascent of sap, may be taken to result similarly from physical conditions. The uppermost part of the gelatinous mass of the plant ramifies as does the lower, but in this case into flattened organs or leaves. Here, as well as everywhere, on the external surfaces of the plant evaporation of water takes place in a manner modified by the specialized character and structure of the surface as well as by the relative humidity, temperature and movements of the air. This transpiration, or loss of water from the exposed surfaces, is a process of such importance that it is impossible for the plant to maintain growth to any extent, or carry out normal development without it. Consequently it has come in for a great deal of attention during the last century. Much of the work has been of a

Fig. 3. Sectional Diagram Showing the Essentials of the Spherical Porous Cup Atmometer with Non-rain-Absorbing Device, as Frequently Arranged. A rubber stopper in the bottom bears besides the supply tube to the first mercury valve, a larger tube for filling. The latter has a mask to serve as zero point and is covered by a loose-fitting cap. Suction through the open tube at extreme left removes the air from the system and fills the whole with water. Mercury in the valves is shown as if evaporation were in progress; when rain occurs the column rises in the right-hand valve and falls in the other.

qualitative character and most of the quantitative measurements have been meaningless, either by reason of the use of fragments of plants or because the calibrations were of a plausible rather than of an analytical character. As a matter of fact, this loss of water from the plant, like many organic activities, is complicated by indirect and accessory functions in such manner that the main processes are difficult to evaluate. It is desirable in all such cases to construct a physical analogue which will reproduce the essential feature of the process to be measured. Notable success in this case has been attained by Professor Livingston who has devised and perfected an evaporimeter consisting of a porous clay cylinder closed at one end, which is kept filled with water (see Fig. 3). The liquid saturates the walls of this vessel and evaporates after the manner in which it would in the plant, excepting for the modifications induced by light and by the incidental structural features of the plant. The exposure of the instrument during any given set of conditions for any period gives data from which the actual evaporation may be calculated. Comparison with measured areas of leaf-surface shows that departures from the normal evaporation are made by the plant, and the departure may be expressed as the *relative transpiration*. This relative transpiration is never more than seven tenths of the evaporation from the instrument, and is generally much less. The evaporimeter has given us a standard and means of measurement by which all of the phases of water-loss with reference to diverse environment, in widely separated localities, and in the different stages of development of the individual may be measured with exactness.

As was fully expected, the exact calibrations have yielded data upon which new conceptions have been erected and new generalizations formulated. Among these may be mentioned that of "incipient desiccation." When the water-loss from an evaporimeter and from a plant is followed throughout the course of a June day at the Desert Laboratory, it is found under certain conditions that the midday maximum of temperature is accompanied by a maximum loss of water from the instrument. When this was compared with the loss from a plant it was seen that in certain cases the increased loss of water from the latter toward the middle of the day was checked.

All other means of interpretation of this lessened water-loss, including a consideration of the partial closure of the stomata, as determined by Lloyd, failing to explain the fluctuation in the middle of the day, recourse was had to determining the amount of water actually present in the leaves at such times. This revealed a deficiency. Briefly put, water was being lost from the membranes of the plants faster than it was being supplied to them with the result that vaporization slackened. This condition was designated as *incipient desiccation* and, as it is not accompanied by any external indications, its discovery was taken to be of great importance, both scientifically and economically, since the efficiency of the leaf as a food-forming organ decreases notably as the incipient drying stage is reached and long before externally visible, wilting or flagging is shown. The skilful agriculturist will, therefore, irrigate his crops not when they wilt but when the proportion of water in the leaves falls below a certain point.

Still another feature of relative transpiration and incipient drying remained to be detected and measured. Evaporation, of course, tends to render heat latent and hence keep down the temperature of leaves. Variations in transpiration should therefore be accompanied by characteristic temperatures. A calorimeter for the requisite measurements was designed by Mrs. E. B. Shreve. Leaves were put into a chamber filled with turpentine which penetrated the tissues quickly and realized the temperatures at once. The temperatures were found to meet expectancies, even in the stages of incipient desiccation, where the lessened water-loss was accompanied by the development of a degree of heat which might affect the efficiency of the leaf in food-formation.

Returning to the figure of the plant as a cylindrical mass of colloids, it is to be said that the water which enters the plant at its roots does not move as in a tube directly to the upper end where it is transpired. The cylinder may in effect be enlarged or variously developed to such shape that a surplus of water accumulates and if the supply be cut off from below the amount on hand may be such that the plant lives for a season, a decade or even longer upon the water on hand. I have carried out a series of measurements upon this phase of the water relations of plants during the last six years and find that many plants of arid regions in South America, North America and Africa show such accumulation of water. The sap of such plants under normal conditions shows about the concentration which gives an osmotic pressure of three to twelve atmospheres. When the supply is cut off the loss of water continues with the result that the concentration increases four or five times. The desiccation of these plants, however, is not simply that of drying out. The rate of loss decreases much more rapidly than would be justifiable on the facts of amount of water present, and one is led to infer that the plant again to be thought of as a cylinder of jelly undergoes changes of its colloids which tend to prevent transpiration. Whether such changes are reversible as in incipient desiccation or not is a matter yet to be determined. Without going into detail at all it may be said that the continued depletion of the store of water of a succulent is responsible for many important features in the life-cycle of the plant, in growth and reproduction and in survival (see Fig. 4).

The consideration of the facts brought to light in a study of the balances or accumulations of water in plants formed a basis for an analysis of the conditions of parasitism in the higher forms. This is primarily a water-relation. When one plant as, for example, the mistletoe, is parasitic on another, such conditions must be present as to cause water to flow from the host to the tissues of the parasite carrying substances in solution. The experimentation in this subject consisted, first of all, in forming artificial parasitical relations between plants in order to ob-

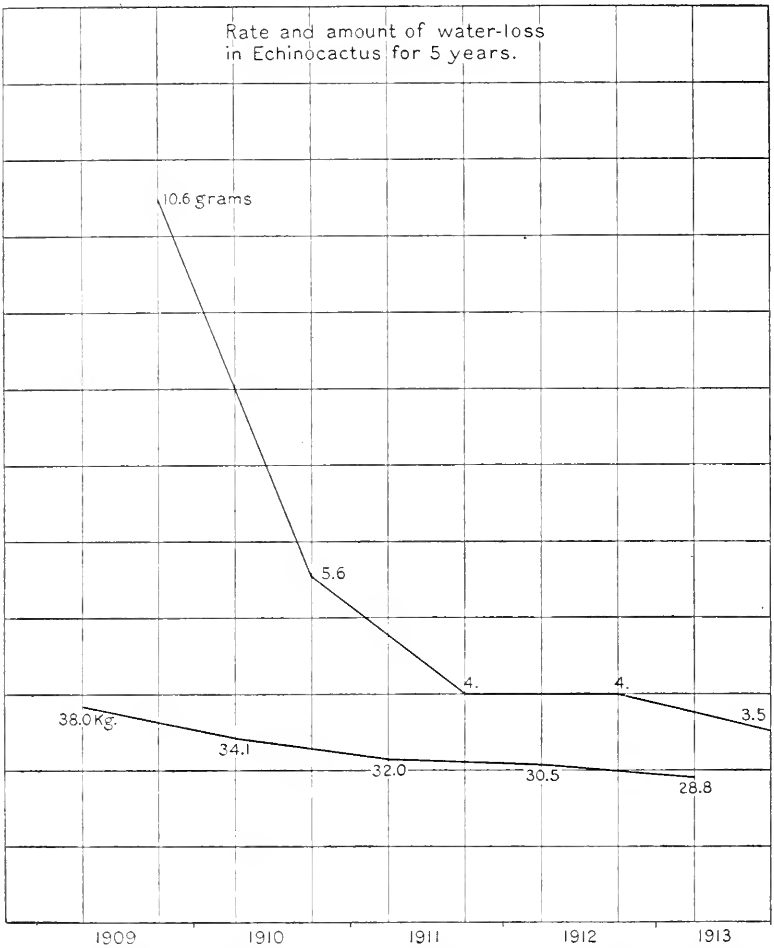



Fig. 4. Graphs Showing the Water Relations of a Large Cylindrical Cactus when Separated from a Source of Supply for Extended Periods. The lower line shows the weight decreasing from 38 kg. to 28.8 kg. in five years. The upper line shows the rate of daily loss which fell from 10.6 g. to 3.5 g. during this time. The rate of loss is not directly proportional to the succulence or amount of water present.

tain a number of couples which might be joined as host and dependent, and also equally important to find others which might not enter into this relation.

The succulents with their accumulations of water offered suitable material and, using these as artificial hosts a number of species were caused to live on them parasitically for months or even years. Having this material, analyses of the sap or watery solutions of the two plants led, as might be expected, to the result that one plant which would live parasitically on another must have a more highly concentrated sap. Not all plants with a high concentration of sap may become parasitic on all those of low concentration, however, for other reasons, some of them seasonal, morphological, etc. (see Fig. 5).

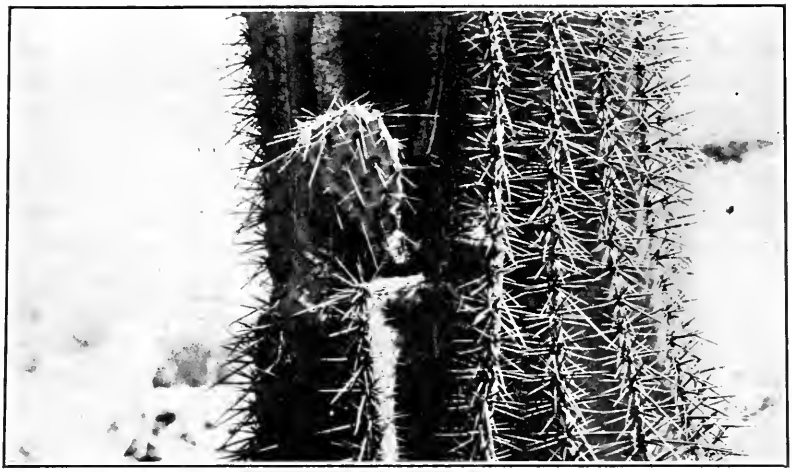


FIG. 5. A JOINT OF *Opuntia Blakeana* ROOTED PARASITICALLY IN A CAVITY IN THE BODY OF *Carnegiea gigantea*, under which condition it has existed for three years

The difficulties in dealing with the mechanical features presented by the soil are such that it has not yet been possible to construct an instrument which would give data analogous to absorption by roots as does the evaporimeter for transpiration by leaves. Developments in this matter are to be hoped for, however. Meanwhile the studies of Dr. Cannon on root-systems and the distribution of water in the soil have yielded some generalizations of no little value in the consideration of the aspects of the vegetation of a region. Among these it is to be mentioned that the treelessness of the immense stretches of western prairie and probably of steppes everywhere is a matter dependent upon the distance below the surface at which the so-called "ground water" or "water table" lies. Trees and forests may be established in such regions when the supply of moisture in the upper layers of the soil are increased by irrigation, conservation of rainfall or whatever artificial means may be employed.

Living matter is a thermal engine in which the energy of various substances is released very slowly by oxidation processes. It is also self-organizing and substances of various kinds entering into its solutions may be reduced and their components rearranged in the form of characteristic constituents and products and in turn become fuel for the engine. Many of these reducing processes are carried on in the presence of light in the plant. Potassium and calcium nitrate, for example, yield nitrites and later ammonia in such a process, and acetic, glycollic, propionic, malic, tartaric and citric acid are broken up, yielding formaldehyde, carbon dioxide and other substances.

The greatest addition to the potential energy of the plant, however, is that in which carbon dioxide from the air enters leaves and in the ensuing process carbohydrates result and oxygen escapes. This photosynthesis is perhaps the most fundamental of all processes in the world of living things, since it is with this action initially that the construction of nearly all organic material is begun. Various theories have been proposed to account for the procedure from the entrance of carbon dioxide into the plant to the formation of sugars, but none of these will stand the test of our critical experiments. Their inadequacy may be ascribed to the fact that the function of the light in the matter is not yet clear. At present we may only say that upon the entrance of carbon dioxide into a leaf it probably unites with potassium to form the bicarbonate, in which salt it is more easily broken up than as if it remained a free acid. Here are then bicarbonate and water in the presence of chlorophyll, the green coloring substance of the plant. The spectrograph of this substance reveals the fact that rays of certain wave-lengths are absorbed by it. In other words, these rays impinging on the chlorophyll change the nature of its electronic movement and cause some disintegration of its structure. The disturbance, whatever it may be, is communicated to the bicarbonates, and to the water, which are reduced, the free oxygen escaping and some simple carbonhydrate resulting. So far we may proceed in complete harmony with known facts. Between this and the appearance of hexoses in the leaf is a wide gap. Once bridged and the full effect of light in the entire course of photosynthesis made out, it may be possible to simulate a process which now takes place only in living tissue, and make available to the race a source of energy all but limitless in its potentialities.

The formulation of plans for this work has necessitated a large number of measurements of intensity and of the reducing effect of light under various conditions and in various places in which experimentation might be carried on, by Dr. Spoehr. Among the noteworthy results of such calibration is the demonstration that the blue-violet rays, direct and skylight, is greater at the Desert Laboratory on a shoulder of the Tucson mountains (2,700 feet) sheltered from the prevailing winds and resultant dust, than on the summit of the Santa Catalina mountains (9,250 feet) in which the skylight is less, but the direct light passes through a layer of air a mile less in thickness than that which reaches the laboratory. Watery vapor and dust particles may account for some of the absorption of light on the summit of the forested mountain slopes.

Our concern with light as a factor of environment however by no means ends with the part it plays in the reduction and combination processes. Its ionization effects are discernible in respiration in all of its separate stages. None of the measurements of the action of this important environic component have proven more interesting than those which have been carried out by Professor H. M. Richards and Dr. Spoehr upon the reduction of the acids in plants. Although formed and present in minute quantities in all plants, yet they accumulate and are present in such quantities in the succulent cacti that facile conditions for experimentations are found. The accumulation goes on during darkness so that at daybreak these plants may contain as much as ten times as much acid as at sunset, the diminution during the day being due to the action of light, the disintegration of the acid resulting in formaldehyde and carbon dioxide. Now growth has long been held to be directly retarded by light, it being supposed that the blue-violet rays especially exerted a fixing or destructive action on living matter which prevented growth. That such action did not take place was established by my own experiments on etiolation previous to 1903. The fact remains, however, that growth-expansions and elongations generally go on more rapidly at night than in daytime, and in the determination of the daily fluctuation of acidity we believe to have hit upon the cause of the difference in the rate of growth by day and by night.

Growth is correlated with hydratation, or increase of the water absorbing capacity and consequent swelling of living matter and cell walls in which osmotic pressure must also play a part. Acids may cause such swelling and increase, and this effect would accumulate with the increasing acidity through the night until daybreak, when light begins to break up the acids, and growth-extension would slacken. Light does, therefore, in finality, retard growth not by its action on the components of living matter as formerly supposed, but by breaking up the compounds which increase the water-absorbing power of protoplasm. The controlling environmental features in the growth and development of vegetation are water-absorption or hydratation and temperature.

Some isolated processes of plants, the course of which runs for a short time, such as the action of enzymes upon the starch, which may be accumulated in a tuber or a seed, the germination of seeds or the development of buds, which depends directly upon the hydrolysis of such food material, are found to conform fairly well with van't Hoff's rule by which the rate of activity is about doubled for every rise of 18° F. above the minimum temperature at which it begins. If the entire development of the plant could be interpreted in the same manner the task of estimating the effect of the temperature factor in environment would be a simple one. This is far from the case, however, as any change in temperature may disturb chemical equilibrium in a dozen ways.

The director began a study of this subject in 1900, and first formulated a method by which the total heat-exposure of a locality in which a plant was growing was calculated in hour-degrees, simply as the product of the number of hours the plant stood above the temperature at which growth began and of the averaged intensities during this period. The method was obviously empirical, as it assumed that the rate of growth was the same at all temperatures above its zero point, which might be freezing or above it.

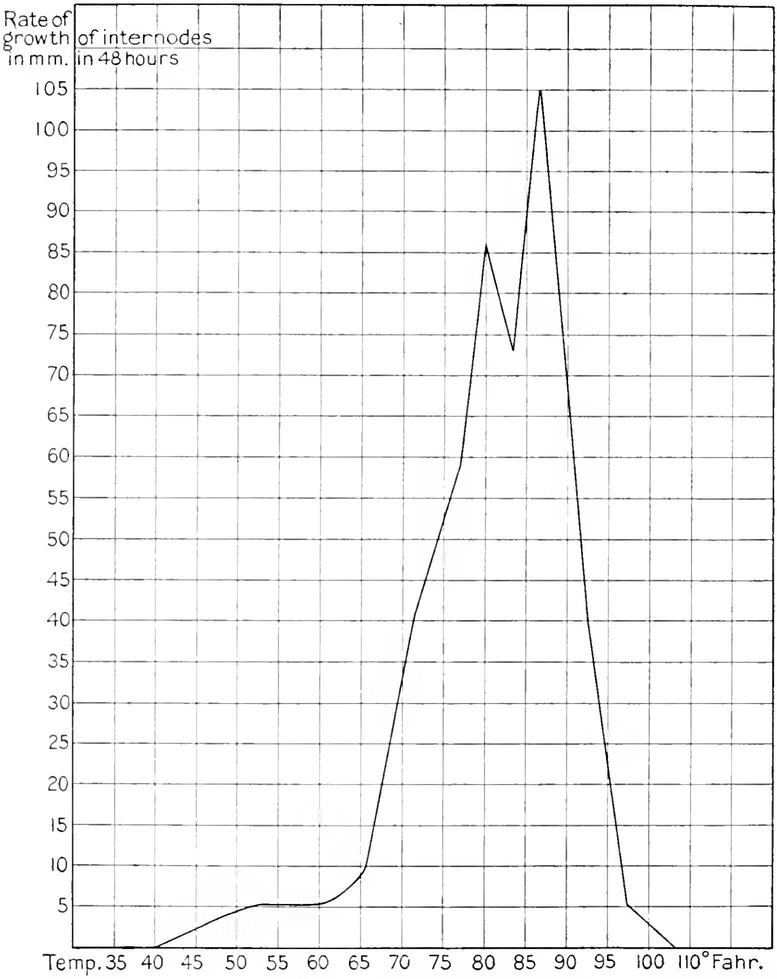



FIG. 6. GRAPH SHOWING RATE OF GROWTH OF SEEDLINGS OF WHEAT AT TEMPERATURES BETWEEN 40° AND 108° F., plotted from data given in text-books of plant physiology.

Next, Professor B. E. Livingston, using the exponential law of chemical velocity in the interpretation of temperature effects, found that survival and distribution of some types of vegetation were explainable upon the temperature integrations arrived at in this manner. This method, however, still depends upon averages or summations of temperature and does not evaluate the higher temperatures correctly as the plant grows fifteen to twenty times as rapidly at its optimum temperature as it does within ten or fifteen degrees of its zero or minimum. The nature of the experiments upon environic effects, for which some method of temperature evaluation was necessary, demanded greater exactness, and it was finally decided that the actual activity of some plant should be used as a standard of measurement, as the effect of temperature upon growth is one in which chemical equilibrium is disturbed in a score of ways and is therefore not expressible by any single or simple formula. This will be obvious upon the inspection of the graph which shows the relation of temperature to the growth of the hypocotyle of wheat plants determined by measuring the rate at constant temperatures for 48 hours (Fig. 6).

From this it may be seen that growth of the stems takes place at a rate of about 4 to 6 mm. in 48 hours at temperatures between 40° and 65° F. Above this the rate rises precipitously until the temperature reaches 80° F., and if it becomes warmer than this a drop ensues during the next few degrees of rise, then the increase is resumed and carried until a temperature of 86.5° F. is reached. Any further rise in temperature definitely checks growth, which ceases entirely at temperatures of 108° F.

This plant was fixed upon because it is widely grown from subtropical to subarctic localities, reliable measurements have been made of its rate, and it may accompany nearly all of the experimental cultures made in our researches. It is proposed, therefore, to integrate the temperature factor in climate in terms of growth of wheat. Any other suitable species might be used as well. The scheme in brief consists in fixing upon an averaged rate of growth between 40° and 65° F. and then for the five-degree intervals up to the optimum and upper limit. The sheet in which the thermograph has made its tracing of the course of the temperature is now ruled into figures bounded by a

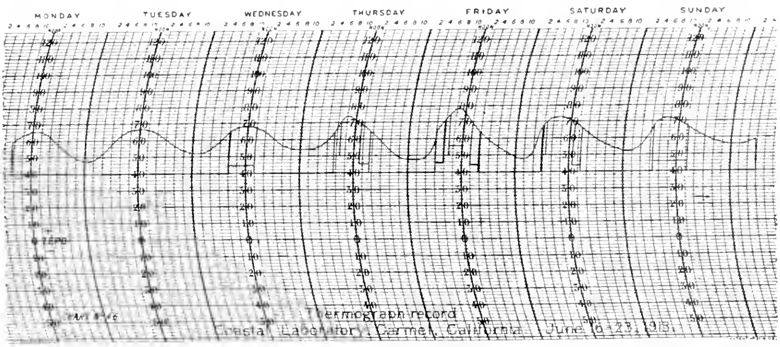



Fig. 7. Thermograph Chart Ruled for Integration in Terms of Rate of Growth. The areas of the separate figures are to be determined by a planimeter and multiplied by the factor expressing the rate of growth prevalent during the period covered by the figures. Record from Coastal Laboratory, June 16–23, 1913.

base line twenty-five degrees below the upper limit of the temperature to be estimated, by arcs of the curves marking the hours, and by the crooked line traced by the pen as a result of changes in temperature, as shown on the accompanying sheet (Fig. 7).

The areas of such figures for temperatures is multiplied by the factor 4.5 for temperatures between 40° and 65° F., and by 20 for temperatures between 65° and 70° F., and by 45 for temperatures

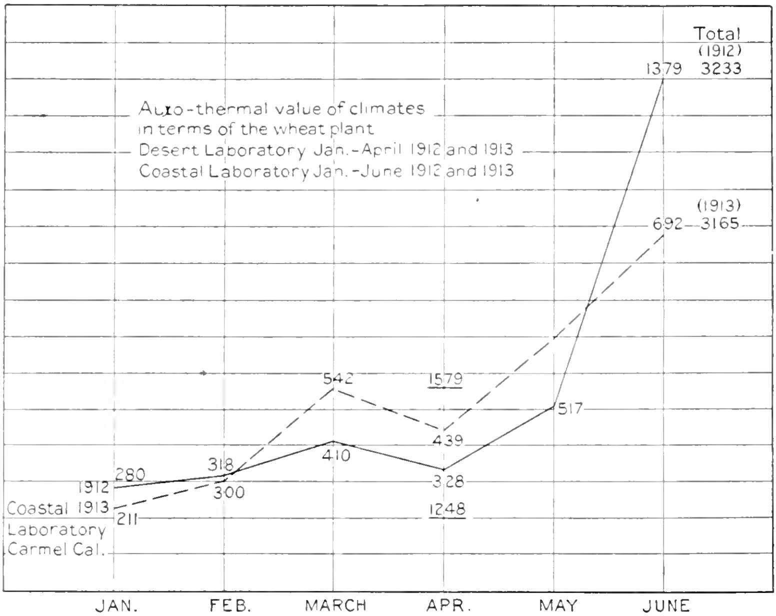



FIG. 8. GROWTH-VALUES DURING THE FIRST SIX MONTHS OF TWO YEARS AT THE COASTAL LABORATORY, CARMEL, CALIF. The solid line shows temperature effects in 1912, the broken line during 1913.

between 70° and 75° F., by 70 for temperatures between 75° and 80° F., by 78 for temperatures between 80° and 86° F., the optimum, etc. Time does not suffice to mention the necessary corrections, or the studies being made for the refinement of the method, but attention may be called to the estimation of the temperature factor by this method at our two main experimental localities during the first four and six months of two years at the Desert Laboratory, and the Coastal Laboratory (Fig. 8). The facts displayed in the accompanying figure go far to explain the divergent action of species under observation in the two places. Studies are now in progress for the redetermination of the factors expressing the rate of growth under the ordinary swing of daily temperatures and for an exacter application of the results.

There is much reason to believe that in the integration of the temperatures and moisture relations by the methods outlined we will be able to identify the causation of the remarkable evolutionary departures exhibited by the beetles in Professor Tower's experiments, and steps are now being taken for the necessary analytical tests for the standardization of temperature effects in terms of protoplasmic activity.

Another phase of temperature effects—concerning energy release in protoplasm—has been studied by Professor Ellsworth Huntington, whose analysis of the records of piece-workers in factories established the fact that the least amount of work is accomplished with open air temperatures below the freezing point and in the neighborhood of zero Fahrenheit. The amount increases slowly, however, up to 28° F., then rapidly to 38°, slowly to 48° and more slowly to the optimum of 58° F., above which the rate and amount declines as the weather becomes warmer. It may seem a far cry from the growth of a wheat plant in California to the muscular action of a factory operative in New England, but both are directly dependent upon the fundamental characters of living matter, especially in its relation to temperature.

The distribution and grouping of organisms on the world's surface is conditioned by the agencies which participate in moving them from place to place and by the presence of conditions suitable for their survival and existence. If all species inhabited every place suitable for them, geography, so far as vegetation is concerned, would be a subject about which many closed chapters might be written. They do not, however, as they have not been carried to all the places in which they might survive, and secondly, the conditions comprising the environic complex are slowly but surely changing, reversibly or irreversibly, practically everywhere on all land surfaces. Under such conditions the dynamics of plant geography assumes an importance not yet realized.

So far we have discussed the results of analyses of our plantations and experimental settings. The geographer, however, needs to have defined for him the principles governing the variations in the various environmental components and of course temperature is an agency which has been drawn upon to account for some of the major features of distribution in geologic as well as present time. Methods and practises that have become conventionalized estimate temperatures by altitude and latitude, the actual data obtained by instrumentation being compiled as mean temperatures, and the averages of maxima and minima. I need but to refer to the measurements of temperature in terms of growth discussed previously to illustrate the inadequacy of these data for agricultural operations.

The obvious and popularly accepted assumption that low valleys are warm and that ridges are cold wind-swept habitats, arising from the conception of surface temperatures as in the main a function of altitude has been followed much too far, and the geographer who bases his generalizations on assumptions of this kind will be due to encounter some extremely disturbing anomalies, some of which have come in for examination and measurement at the Desert Laboratory by Dr. Shreve.

Forested slopes and bare rocky surfaces do not lose heat at the same rate at night or warm up at the same rate in the daytime. The air cooled on the bare slopes flows down the declivity, collecting in the valleys beneath as would water. Consequently the main building of the Desert Laboratory, 400 feet above the station at the base of Tumamoc hill, is ordinarily 15° to 20° F. warmer than the plantation below at night. This exercises marked influence on the organisms inhabiting these places. In the Santa Catalina mountains in which much of our experimentation is done, this inversion of temperature and collection of cold air operates to give valleys climates equivalent in temperature to the great ridges half a vertical mile higher, in illustration of which it is cited that the cacti, characteristic of warm places, spread highest on the crests of the mountain ridges. The divergence of the temperatures from the normal rate to be expected from increase of temperature may be also illustrated by the following facts:

During the low extremes which characterized the climate of the southwest during the first month of the present year the minima were as follows:

| | Actual | Estimated |
|---|---|---|
| Desert Laboratory (2,700 feet) .............. | 17° F. | .... |
| Breeding plantation (2,300 feet) ............. | 1° F. | 18° F. |
| Xero-montane plantation (6,000 feet) .......... | —6° F. | 7.6° F. |
| Rim of Bear Canon (7,000 feet) ............. | .5° F. | 3° F. |
| Montane plantation (8,000 feet) .............. | —2° F. | ±.5° F. |

If now these places are plotted on a scale in which the vertical element was magnified, but the fall in temperature was computed on the basis of one degree for about every three hundred feet in elevation, it may be seen that the 2,300 feet locality diverges 17° F. from the expectancy by reason of cold air drainage, the 6,000 feet locality is 13.6° F. colder, the 7,000 feet location 2.5° F. colder and the 8,000 feet location 2.5° F. colder. The difference between the mountain top at 8,000 feet and the Desert Laboratory as correspondent to within the limit of possible error, but between these two places ranges the vegetation from the subtropics to the pines under conditions of temperature largely influenced by the relief and orography. The facts which have been brought to light in this single thermometric traverse of a valley and up a mountain slope shows the need of extended surveys for the purpose of evaluating the temperature factor as an agency affecting the distribution of organisms, and when our generalizations can be broadly based and rationally formulated we may also be in a position to furnish the paleontologist with criteria for the better interpretation of the occurrence of the plants and animals found in ancient deposits.

The number of things to be considered in the study of the comparative effects of the different climatic complexes represented at our various plantations make necessary long extended observations coupled with analytical tests before we may hope to reach any conclusions that may be concisely expressed or widely applied.

The results obtained by the studies which have just been brought to a stage of completion of the Salton Sea furnish us with some very suggestive facts as to the influence of the substratum upon organisms. The waters of this sea when it stood at maximum level in 1907 contained about one fourth of one per cent. of dissolved material, principally salts of sodium, potassium and magnesium. The recession of the lake by evaporation left bare a new strip of strand each year, which was saturated with a solution differing from that of the preceding year by about one fifth of one per cent. in concentration with some changes in relative value of the various substances, especially the calcium and magnesium. Accompanying such conditions, an *Aster*, a *Prosopis*, a *Scirpus* and an *Atriplex* have shown variations not hitherto seen in these species. Especial interest attaches to these occurrences from the fact that there are seven species endemic below the level which the ancient body of water, Blake Sea, must have reached three or four centuries ago. In other words, these seven species are found nowhere but on the beaches of the lake and there is a strong presumption that this restricted occurrence is due to their origination in the place and that they have not spread beyond the ancient sea-bed.

The facts brought out in the foregoing discussion are presented not so much to denote actual progress in our researches as to illustrate the character of some of the problems under consideration. The inquiry as to the integrity of purpose and validity of results of such work is a question which may rightly be directed toward every project which absorbs funds and consumes the time and energy of the investigator and the worker. Something of the wider purposes and fundamental character of the problems attacked are suggested by the results and plans which have been discussed. In addition it seems necessary to say to those who mistakenly attribute a directly economic purpose to the Desert Laboratory that none of its facilities are devoted to agricultural experimentation. This is a function especially pertaining to the government, and so far as our own is concerned a function that is most efficiently carried out. It is clear, however, that the data being accumulated at the Desert Laboratory may in time constitute an important contribution to the physical and biological principles to be considered in the occupation and utilization of arid regions. When it is taken into account that the world-wide progress of civilization with its attendant extended occupancy of the surface of the earth has brought the race to a point where it must consider seriously methods for the more intensive use of the areas already occupied, and also bring into usefulness the arid areas which comprise one fifth of the total land area, the importance of this possibility may be realized.

# THE THEORY OF RELATIVITY AND THE NEW MECHANICS

By Professor WILLIAM MARSHALL
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HE who elects to write on a mathematical topic is confronted with a choice between two evils. He may decide to handle his subject mathematically, using the conventional mathematical symbols, and whatever facts, formulas and equations the subject may demand—save himself who can! Or he may choose to abandon all mathematical symbols, formulas and equations, and attempt to translate into the vernacular this language which the mathematician speaks so fluently. In the one case there results a finished article which only the elect understand, in the other, only a rather crude and clumsy approximation to the truth. A similar condition exists in all highly specialized branches of learning, but it can safely be said that in no other science must one fare so far, and accumulate so much knowledge on the way, in order to investigate or even understand new problems. And so it is with some trepidation that the attempt is made to discuss in the following pages one of the newest and most important branches of mathematical activity. For the writer has chosen the second evil, and, deprived of his formulas, to borrow a figure of Poincaré's, finds himself a cripple without his crutches.

After this mutually encouraging prologue let us introduce the subject with a definition. What is relativity? By relativity, the theory of relativity, the principle of relativity, the doctrine of relativity, is meant a new conception of the fundamental ideas of mechanics. By the relativity mechanics, or as we may sometimes say, the new mechanics, is meant that body of doctrine which is based on these new conceptions. Now this is a very simple definition and one which would be perfectly comprehensible to everybody, provided the four following points were made clear: first, what are the fundamental concepts of mechanics, second, what are the classical notions about them, third, how are these modified by the new relativity principles, and fourth, how did it come about that we have been forced to change our notions of these fundamental concepts which have not been questioned since the time of Newton? These four questions will now be discussed, though perhaps not in this order. The results reached are, to say the least, amazing, but perhaps our astonishment will not be greater than it was when first we learned, or heard rather, that the earth is round, and that there are persons directly opposite us who do not fall off, and stranger yet, do not realize that they are in any immediate danger of doing so.

In the first place then, how has it come about that our conceptions of the fundamental notions of mechanics have been proved wanting? This crime like many another may safely be laid at the door of the physicists, those restless beings who, with their eternal experimenting, are continually raising disturbing ghosts, and then frantically imploring the aid of the mathematicians in order to exorcise them. Let us briefly consider the experiment which led us into those difficulties from which the principle of relativity alone apparently can extricate us.

Consider a source of sound *A* at rest (Fig. 1), and surrounded by air, in which sound is propagated, also at rest. Now, as every schoolboy knows, the time taken for sound to go to *B* is the same as that taken to go to *C*, if *B* and *C* are at the same distance from *A*. The same is true

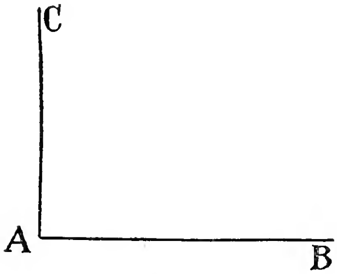


Fig. 1.

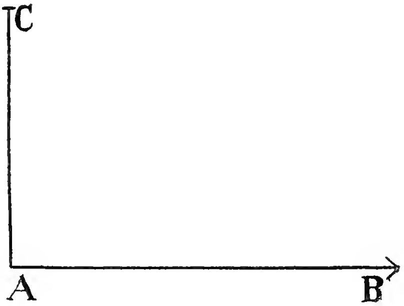


Fig. 2.

also if *A*, *B* and *C* are all moving with uniform velocity in any direction, *carrying the air with them*. This may be realized by a closed railway car or a boat. But if the points *A*, *B*, and *C* are moving with uniform velocity, and the air is at rest relative to them, or what is the same thing, if they are at rest and the air is moving past them with uniform velocity, the state of affairs is very different. If the three points are moving in the direction indicated by the arrow (Fig. 2), and if the air is at rest, and if a sound wave is sent out from *A*, then the time required for this sound wave to go from *A* to *C* is *not the same* as that required to go from *A* to *B*. Now as sound is propagated in air, so is light in an imaginary medium, the ether. Moreover, this ether is stationary, as many experiments show, and the earth is moving through it, in its path around the sun with a considerable velocity. Therefore we have exactly the same case as before, and it should be very easy to show that the velocity of light in a direction perpendicular to the earth's direction of motion is different from that in a direction which coincides with it. But a famous experiment of Michelson and Morley, carried out with the utmost precision, showed not the slightest difference in these velocities. So fundamental are these two simple experimental facts, that it will be worth while to repeat them in slightly different form. If the three points *A, B, C* (Fig. 2), are moving to the right with a uniform unknown velocity through still air, and if a sound wave were sent out from *A*, it would be exceedingly simple to determine the velocity of the point *A* by a comparison of the time necessary for sound to travel from *A* to *B* and from *A* to *C*. But now if the same three points move through stationary ether, and if the wave emanating from *A* is a light wave, there is absolutely no way in which an observer connected with these three points can determine whether he is moving or not. Thus we are, in consequence of the Michelson and Morley experiment, driven to the first fundamental postulate of relativity: The uniform velocity of a body can not be determined by experiments made by observers on the body.

Consider now one of the fundamental concepts of mechanics, time. Physicists have not attempted to define it, admitting the impossibility of a definition, but still insisting that this impossibility was not owing to our lack of knowledge, but was due to the fact that there are no simpler concepts in terms of which time can be defined. As Newton says:

> Absolute and real time flows on equably, having no relation in itself or in its nature to any external object.

Let us examine this statement, which embodies fairly our notion of time, in the light of the first fundamental principle of relativity just laid down. Suppose *A* and *B* (Fig. 3) are two observers, some distance apart, and they wish to set their clocks together. At a given instant agreed upon before hand, *A* sends out a signal, by wireless if you wish, and *B* sets his clock at this instant. But obviously the signal has taken some time to pass from *A* to *B*, so *B*'s clock is slow. But this seems easy to correct; *B* sends a signal and *A* receives, and they take the mean of the correction. But says the first principle of relativity, both *A* and *B* are moving through the ether with a velocity which neither knows, and which neither can know, and therefore the time taken for the signal to pass from *A* to *B* is not the same as that taken to pass from *B* to *A*. Therefore the clocks are not together, and never can be, and when *A*'s clock indicates half-past two, *B*'s does not indicate this instant, and worse yet, there is absolutely no way of determining what time it does indicate. Time then is purely a local affair. The well-known phrase, "at the same instant" has no meaning for *A* and *B*, unless a definition be laid down giving it a meaning. The "now" of *A* may be the "past" or "future" of *B*. To state the case in still other words, two events can no more happen simultaneously at two different places, than can two bodies occupy the same position.

Fig. 3.

But doubtless the reader is anxious to say, this matter of adjusting the clocks together can still be settled. Let there be two clocks having the same rate at a point *A*, and let them be set together. Then let one of them be carried to the point *B,* can not they then be said to be together? Let us examine this relative motion of one clock with respect to another, in the light of the first principle of relativity. Let there be two observers as before with identical clocks, and for simplicity, suppose *A* is at rest and *B* moving on the line *BX* (Fig. 4). Suppose further *BX* parallel to *AY*. Let now *A* send out a light signal which is reflected on the line *BX* and returns to *A*. The signal has then traveled twice the distance between the lines in a certain time. *B* then repeats the same experiment, for, as far as he knows, he is at rest, and *A* moving in the opposite direction. The signal traverses twice the distance between the lines, and *B*'s clock must record the same interval of time as *A*'s did. But now suppose *B*'s experiment is visible to *A*. He sees the signal leave *B,* traverse the distance between the lines, and return, *but not to the point B,* but to the point to which *B* has moved in consequence of his velocity. That is, *A* sees the experiment as in Fig. 5, where the position of *B′* depends on *B*'s velocity with respect to *A*. The state of affairs is to *A* then simply this: A signal with a certain known velocity has traversed the distance *ABA* while his (*A*'s) clock has registered a certain time interval. The same signal, moving with the same velocity, has traversed the greater distance *BCB′* while *B*'s clock registers exactly the same time interval. The only conclusion is that to *A, B*'s clock appears to be running slow as we say, and its rate will depend on the relative velocity of *A* and *B*. Thus we are led to a second conclusion regarding time in the relativity mechanics. To an observer on one body the time unit of another body moving relative to the first body varies with this relative velocity. This last conclusion regarding time is certainly staggering, for it takes away from us what we have long regarded as its most distinguishing characteristic, namely, its steady, inexorable, onward flow, which recognizes neither place nor position nor movement nor anything else. But now in the new mechanics it appears only as a relative notion, just as velocity is. There is no more reason why two beings should be living at the same rate, to coin an expression, than that two railroad trains should be running at the same speed. It is no longer a figure of speech to say that a thousand years are but as yesterday when it is past, but a

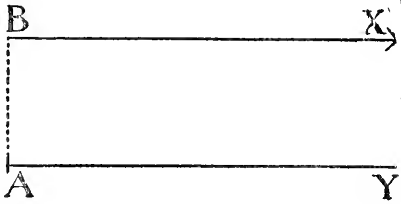


FIG. 4.

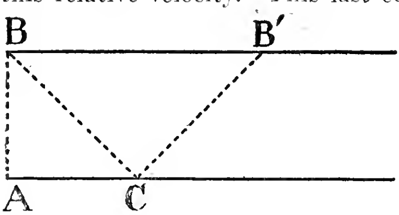


FIG. 5.

thousand years and yesterday are actually the same time interval provided the bodies on which these two times are measured have a sufficiently high relative velocity.

It is to be noted that in the above discussion, use was made of the fact that the light signal sent out by *B* appeared to *A* to have the same velocity as one sent out by *A* himself. This stated in general terms, the velocity of light in free space appears the same to all observers, regardless of the motion of the source of light or of the observer, is the second fundamental postulate of relativity. It is an assumption pure and simple, reasonable on account of the analogy between sound and light, and does not contradict any known facts.

Now there is a second fundamental concept of mechanics, very much resembling time in that we are unable to define it, namely, space. Instead of being one-dimensional, as is time, it is three-dimensional, which is not an essential difference. From the days of Newton and Galileo, physicists have agreed that space like time is everywhere the same, and that it too is independent of any motion or external object. To fix the ideas, consider any one of the units in measuring length, the yard, for example. To be sure, the bar of wood or iron, which in length more or less nearly represents this yard, may vary, as every one knows, in its dimensions, on account of varying temperature or pressure or humidity, or what not, but the yard itself, this unit of linear space which we have arbitrarily chosen, according to all our preconceived notions, neither depends on place nor position, nor motion, nor any other thinkable thing. But let us follow through another imaginary experiment in the light of the two fundamental postulates of relativity. Consider again our two observers *A* and *B* (Fig. 6), each furnished with a clock and a yardstick, *A* at rest, *B* moving in the direction indicated by the arrow. Suppose *A* sends out a light signal and adjusts a mirror at *C* say, so that a ray of light goes from *A* to *C* and returns in say one second. *A* then measures the distance *AC* with his yardstick and finds a certain number. Then *B*, supposing that he himself is at rest and *A* in motion, sends out a light signal and adjusts a mirror at *D* so that a ray travels the distance *BD* and back again in one second of his time. *B* then measures the distance *BD* with his yardstick, and since the velocity of light is the same in any system, *B* comes out with the same number of units of length in *BD* as *A* found in *AC*. But *A* watching *B*'s experiment sees two remarkable facts: first, that the light has not traversed the distance *BDB* at all, but the greater distance *BD′B′* (Fig. 7), where *D′* and *B′* are the points, respectively, to which *D* and *B*

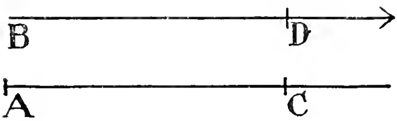


Fig. 6.

have moved in consequence of the motion; second, since *B*'s clock is running slow, the time taken for light to traverse this too great distance is itself too great. Now if too great a distance is traversed in too great a time, then the velocity will remain the same provided the factor which multiplies the distance is the same as that which multiplies the time.

FIG. 7.

But unfortunately, or fortunately, a very little mathematics shows that this multiplier is *not* the same. *A* sees too short a distance being traversed by light in a second of time, and therefore *B*'s yardstick is too short, and by an amount depending on the relative velocity of *A* and *B*. Thus we are led to the astonishing general conclusion of the relativity theory with reference to length: If two bodies are moving relative to each other, then to an observer on the one, the unit of length of the other, measured in the direction of this relative velocity, appears to be shortened by an amount depending on this relative velocity. This shortening must not be looked upon as due to the resistance of any medium, but, as Minkowski puts it, must be regarded as purely a gift of the gods, a necessary accompaniment of the condition of motion. The same objection might be raised here as in the case of the time unit. Perhaps the length of the yardstick *appears* to change, but does the real length change? But the answer is, there is no way of determining the real length, or more exactly, the words real length have no meaning. Neither *A* nor *B* can determine whether he is in motion or at rest absolutely, and if *B* compares his measure with another one traveling with him, he learns nothing, and if he compares it with one in motion relative to him, he finds the two of different length, just as *A* did.

This startling fact, that a railway train as it whizzes past us is shorter than the same train at rest, is at first a trifle disturbing, but how much of our amazement is due to our experience, or lack of it. A certain African king, on beholding white men for the first time, reasoned that as all men were black, these beings, being white, could not be men. Are we any more logical when we say that since in our experience no yardsticks have varied appreciably on account of their velocity, hence it is absurd to admit the possibility of such a thing.

Perhaps it might be well at this point to give some idea of the size of these apparent changes in the length of the time unit and the space unit, although the magnitude is a matter of secondary importance. The whole history of physics is a record of continual striving after more exact measurements, and a fitting of theory to meet new corrections, however small. So it need not occasion surprise to learn that these differences are exceedingly minute; the amazing thing, and the thing of scientific interest, is that they exist at all. If we consider the velocity of the earth in its orbit, which is about 19 miles per second, the shortening of the earth's diameter due to this velocity as seen by an observer at rest relative to the earth would be approximately a couple of inches only. Similarly for the relative motion of the earth and the sun, the shortening of the time unit would be approximately one second in five years. Even if this were the highest relative velocity known, the results would still be of importance, but the earth is by no means the most rapid in its movement of the heavenly bodies, while the velocity of the radium discharge is some thousand times the velocity of the most rapidly moving planet.

In addition to space and time there is a third fundamental concept of mechanics, though the physicists have not yet settled to the satisfaction of everybody whether it is force or mass. But in any case, the one taken as the fundamental motion, mass say, is, in the classical mechanics, independent of the velocity. Mass is usually defined in physics as the quantity of matter in a body, which means simply that there is associated with every body a certain indestructible something, apart from its size and shape, independent of its position or motion with respect to the observer, or with respect to other masses. But in the relativity mechanics this primary concept fares no better than the other ones, space and time. Without going into the details of the argument by means of which the new results are obtained, and this argument, and the experiment underlying it, are by no means simple, it may suffice to say that the mass of a body must also be looked upon as depending on the velocity of the body. This result would seem at first glance to introduce an unnecessary and almost impossible complication in all the considerations of mechanics, but as a matter of fact exactly the opposite is true. It has been known for some time, that electrons moving with the great velocity of the electric discharge, have suffered an apparent increase of mass or inertia due to this velocity, so that physicists for some time have been accustomed to speak of material mass and electromagnetic mass. But now in the light of the principles of relativity, this distinction between material mass and electromagnetic mass is lost, and a great gain in generality is made. *All* masses depend on velocity and it is only because the velocity of the electric discharge approaches that of light, that the change in mass becomes striking. This perhaps may be looked upon as one of the most important of the consequences of the theory of relativity in that it subjects electromagnetic phenomena to those laws which underlie the motions of ordinary bodies.

In consequence of this revision of our notions of space, time and mass, there result changes in the derived concepts of mechanics, and in the relations between them. In fact the whole subject of mechanics has had to be rewritten on this new basis, and a large part of the work of those interested in the relativity theory has been the building up of the mathematics of the new subject. Some of the conclusions, however, can be understood without much mathematics. For example, we can no longer speak of a particle moving in space, nor can we speak of an event as occurring at a certain time. Space and time are not independent things, so that when the position of a point is mentioned, there must also be given the instant at which it occupied this position. The details of this idea, as first worked out by Minkowski, may be briefly stated. With every point in space there is associated a certain instant of time, or to drop into the language of mathematics for a moment, a point is determined by four coordinates, three in space and one in time. We still use the words space and time out of respect for the memory of these departed ideas, but a new term including them both is actually in use. Such a combination, *i. e.*, a certain something with its four coordinates, is called by Minkowski a *world point.* If this world point takes a new position, it has four new coordinates, and as it moves it traces out in what Minkowski calls the *world,* a *world-line.* Such a world-line gives us then a sort of picture of the eternal life history of any point, and the so-called laws of nature can be nothing else than statements of the relations between these world-lines. Some of the logical consequences of this world-postulate of Minkowski appear to the untrained mind as bordering on the fantastic. For example, the apparatus for measuring in the Minkowskian world is an extraordinarily long rod carrying a length scale and a time scale, with their zeros in coincidence, together with a clock mechanism which moves a hand, not around a circle as in the ordinary clock, but along the scale graduated in hours, minutes and seconds.

Some of the conclusions of the relativity mechanics with reference to velocity are worth noting. In the classical mechanics we were accustomed to reason in the following way: Consider a body with a certain mass at rest. If it be given certain impulse, as we say, it takes on a certain velocity. The same impulse again applied doubles this velocity, and so on, so that the velocity can be increased indefinitely, and can be made greater than any assigned quantity. But in the relativity mechanics, a certain impulse produces a certain velocity, to be sure; this impulse applied again does not double the velocity; a third equal impulse increases the velocity but by a still less amount, and so on, the upper limit of the velocity which can be given to a body being the velocity of light itself. This statement is not without its parallel in another branch of physics. There is in heat what we call the absolute zero, a value of the temperature which according to the present theory is the lower limit of the temperature as a body is indefinitely cooled. No velocity then greater than the velocity of light is admitted in the relativity mechanics, which fact carries with it the necessity for a revision of our notion of gravitational action, which has been looked upon as instantaneous.

In consequence of the change in our ideas of velocity, there results a change in one of the most widely employed laws of velocity, namely the parallelogram law. Briefly stated, in the relativity mechanics, the composition of velocities by means of the parallelogram law is no longer allowable. This follows evidently from the fact that there is an upper limit for the velocity of a material body, and if the parallelogram law were to hold, it would be easy to imagine two velocities which would combine into a velocity greater than that of light. This failure of the parallelogram law to hold is to the mathematician a very disturbing conclusion, more heretical perhaps than the new doctrines regarding space and time.

Another striking consequence of the relativity theory is that the hypothesis of an ether can now be abandoned. As is well known, there have been two theories advanced in order to explain the phenomena connected with light, the emission theory which asserts that light effect is due to the impinging of particles actually sent out by the source of light, and the wave theory which assumes that the sensation we call light is due to a wave in a hypothetical universal medium, the ether. Needless to say this latter theory is the only one which recently has received any support. And now the relativists assert that the logical thing to do is to abandon the hypothesis of an ether. For they reason that not only has it been impossible to demonstrate the existence of an ether, but we have now arrived at the point where we can safely say that at no time in the future will any one be able to prove its existence. And yet the abandoning of the ether hypothesis places one in a very embarrassing position logically, as the three following statements would indicate:

1. The Michelson and Morley experiment was only possible on the basis of an ether hypothesis.

2. From this experiment, follow the essential principles of the relativity theory.

3. The relativity theory now denies the existence of the ether. Whether there is anything more in this state of affairs than mere filial ingratitude is no question for a mathematician.

It should perhaps be pointed out somewhat more explicitly that these changes in the units of time, space and mass, and in those units depending on them, are changes which are ordinarily looked upon as psychological and not physical. If we imagine that $A$ has a clock and that about him move any number of observers, $B, C, D, \ldots$, in different directions and with different velocities, each one of these observers sees $A$'s clock running at a different rate. Now the actual physical state of $A$'s clock, if there is such a state, is not affected by what each observer thinks of it; but the difficulty is that there is no way for any one except $A$ to get at the actual state of $A$'s clock. We are then driven to one of the two alternatives: Either we must give up all notion of time at all, for bodies in relative motion, or we must define it in such a way as will free it of this ambiguity, and this is exactly what the relativity mechanics attempts to do.

Any discussion of the theory of relativity would be hardly satisfactory without a brief survey of the history of the development of the subject. As has been stated, for many years the ether theory of light has found general acceptance, and up to about twenty-five years ago practically all of the known phenomena of light, electricity and magnetism were explained on the basis of this theory. This hypothetical ether was stationary, surrounded and permeated all objects, did not, however, offer any resistance to the motion of ponderable matter. There came then, in 1887, into this fairly satisfactory state of affairs, the famous Michelson and Morley experiment. This experiment was directly undertaken to discover, if possible, the so-called ether drift.

In this experiment, the apparatus was the most perfect that the skill of man could devise, and the operator was perhaps one of the most skilful observers in the world, but in spite of all this no result was obtained. Physicists were then driven to seek some theory which would explain this experiment, but with varying success. It was proposed that the ether was carried along with the earth, but a host of experiments show this untenable. It was suggested that the velocity of light depends on the velocity of the source of light, but here again there were too many experiments to the contrary. Michelson himself offered no theory, though he suggested that the negative result could be accounted for by supposing that the apparatus underwent a shortening in the direction of the velocity and due to the velocity, just enough to compensate for the difference in path. This idea was later, in 1892, developed by Lorentz, a Dutch physicist, and under the name of the Lorentz-shortening hypothesis has had a dignified following. The Michelson and Morley experiment, together with certain others undertaken for the same purpose, remained for a number of years as an unexplained fact—a contradiction to ascertained well-established and orderly physical theory. Then there appeared in 1905, in the *Annalen der Physik,* a modest article by A. Einstein, of Bern, Switzerland, entitled, "Concerning the Electrodynamics of Moving Bodies." In this article Einstein, in a very unassuming way, and yet in all confidence, boldly attacked the problem and showed that the astonishing results concerning space and time which we have just considered, all follow very naturally from very simple assumptions. Naturally a large part of his paper was devoted to the mathematical side—to the deduction of the equations of transformation which express mathematically the relation between two systems moving relative to each other. It may safely be said that this article laid the foundation of the relativity theory.

Einstein's article created no great stir at the time, but within a couple of years his theory was claiming the attention of a number of prominent mathematicians and physicists. Minkowski, a German mathematician of the first rank, just at this time turning his attention to mathematical physics, came out in 1909 with his famous world postulate, which has been briefly described. It is interesting to note that within a year translations of Minkowski's article appeared in English, French and Italian, and that extensions of his theories have occupied the attention of a number of Germany's most famous mathematicians. Next Poincaré, perhaps the most brilliant mathematician of the last quarter century, stamped the relativity theory with the unofficial approval of French science, and Lorentz, of Holland, one of the most famous in a land of famous physicists, aided materially to the development of the subject. Thus we find within five years of the appearance of Einstein's article, a fairly consistent body of doctrine developed, and accepted to a surprising degree by many of the prominent mathematical physicists of the foremost scientific nations. No sooner was the theory in a fairly satisfactory condition, than the attempt was made to verify some of the hypotheses by direct experiment. Naturally the difficulties in the way of such experimental verification were very great—insurmountable in fact for many experiments, since no two observers could move relative to each other with a velocity approaching that of light. But the change in mass of a moving electron could be measured, and a qualitative experiment by Kaufmann, and a quantitative one by Bucherer gave results which were in good agreement with the theoretical equations. It was the hope of the astronomers that the new theory would account for the long-outstanding disagreement between the calculated and the observed motion of Mercury's perihelion, but while the relativity mechanics gave a correction in the right direction, it was not sufficient. To bring this very brief historical sketch down to the present time, it will perhaps be sufficient to state that this theory is at present claiming the attention of a large number of prominent mathematicians and physicists. The details are being worked out, the postulates are being subjected to careful mathematical investigation, and every opportunity is being taken to substantiate experimentally those portions of the theory which admit of experimental verification. Practically all of the work which has been done is scattered through research journals in some six languages, so that it is not very accessible. Some idea of the number of articles published may be obtained from the fact that a certain incomplete bibliography contains the names of some fifty-odd articles, all devoted to some phase of this subject—varying all the way from the soundest mathematical treatment, at the one end of the scale, to the most absurd philosophical discussion at the other. And these fifty or more articles include only those in three languages, only those which an ordinary mathematician and physicist could read without too great an expenditure of time and energy, and with few exceptions, only those which could be found in a rather meager scientific library.

In spite of the fact that the relativity theory rests on a firm basis of experiment, and upon logical deductions from such experiments, and notwithstanding also that this theory is remarkably self-consistent, and is in fact the only theory which at present seems to agree with all the facts, nevertheless it perhaps goes without saying that it has not been universally accepted. Some objections to the theory have been advanced by men of good standing in the world of physics, and a fair and impartial presentation of the subject would of necessity include a brief statement of these objections. I shall not attempt to answer these objections. Those who have adopted the relativity theory seem in no wise concerned with the arguments put forward against it. In fact, if there is one thing which impresses the reader of the articles on relativity, it is the calm assurance of the advocates of this theory that they are right. Naturally the theory and its consequences have been criticized by a host of persons of small scientific training, but it will not be necessary to mention these arguments. They are the sort of objections which no doubt Galileo had to meet and answer in his famous controversy with the Inquisition. Fortunately for the cause of science, however, the authority back of these arguments is not what it was in Galileo's time, for it is not at all certain just how many of those who have enthusiastically embraced relativity would go to prison in defence of the dogma that one man's now is another man's past, or would allow themselves to be led to the stake rather than deny the doctrine that the length of a yardstick depends upon whether one happens to be measuring north and south with it, or east and west.

In general it may be said that the chief objection to the relativity theory is that it is too artificial. The end and aim of the science of physics is to describe the phenomena which occur in nature, in the simplest manner which is consistent with completeness, and the objectors to the relativity theory urge that this theory and especially its consequences, are not simple and intelligible to the average intellect. Consider, for example, the theory which explains the behavior of a gas by means of solid elastic spheres. This theory may be clumsy, but it is readily understood, rests upon an analogy with things which can be seen and felt, in other words is built up of elements essentially simple. But the objectors to the relativity theory say that it is based on ideas of time and space which are not now and which never can be intelligible to the human mind. They claim that the universe has a real existence quite apart from what any one thinks about it, and that this real universe, through the human senses, impresses upon the normal mind certain simple notions which can not be changed at will. Minkowski's famous world-postulate practically assumes a four-dimensional space in which all phenomena occur, and this say the objectors, on account of the construction of the human mind, can never be intelligible to any one in spite of its mathematical simplicity. They insist that the words space and time, as names for two distinct concepts, are not only convenient, but necessary. Nor can any description of phenomena in terms of a time which is a function of the velocity of the body on which the time is measured ever be satisfactory, simply because the human mind can not now nor can it ever appreciate the existence of such a time. To sum up, then, this model of the universe which the relativists have constructed in order to explain the universe, can never satisfactorily do this, for the reason that it can never be intelligible to everybody. It is a mathematical theory and can not be satisfactory to those lacking the mathematician's sixth sense.

A second serious objection urged against the relativity theory is that it has practically abandoned the hypothesis of an ether, without furnishing a satisfactory substitute for this hypothesis. As has been previously stated, the very experiment which the relativity theory seeks to explain depends on interference phenomena which are only satisfactorily accounted for on the hypothesis of an ether. Then too, there are in electromagnetism certain equations of fundamental importance, known as the Maxwell equations, and it is perhaps just as important that the relativity theory retain these equations, as it is that it explain the Michelson and Morley experiment. But the electro-magnetic equations were deduced on the hypothesis of an ether, and can be explained, or at least have been explained only on the hypothesis that there is some such medium in which the electric and magnetic forces exist. So, say the objectors to the relativity theory, the relativists are in the same illogical (or worse) position that they occupy with reference to the Michelson and Morley experiment, in that they deny the existence of the medium which made possible the Maxwell equations, which equations the relativity theory must retain at any cost. Professor Magie, of Princeton, who states with great clearness the principal objections to the theory, waxes fairly indignant on this point, and compares the relativists to Baron Munchausen, who lengthened a rope which he needed to escape from prison, by cutting off a piece from the upper end and splicing it on the lower. The objectors to the relativity theory point out that there have been advocated only two theories which have explained with any success the propagation of light and other phenomena connected with light, and that of these two, only the ether theory has survived. To abandon it at this time would mean the giving up of a theory which lies at the foundation of all the great advances which have been made in the field of speculative physics.

It remains finally to ask and perhaps also to answer the question, whither will all this discussion of relativity lead us, and what is the chief end and aim and hope of those interested in the relativity theory. The answer will depend upon the point of view. To the mathematician the whole theory presents a consistent mathematical structure, based on certain assumed or demonstrated fundamental postulates. As a finished piece of mathematical investigation, it is, and of necessity must remain, of theoretical interest, even though it be finally abandoned by the physicists. The theory has been particularly pleasing to the mathematician in that it is a generalization of the Newtonian mechanics, and includes this latter as a special case. Many of the important formulas of the relativity mechanics, which contain the constant denoting the velocity of light become, on putting this velocity equal to infinity, the ordinary formulas of the Newtonian mechanics. Generality is to the mathematician what the philosopher's stone was to the alchemist, and just as the search for the one laid the foundation of modern chemistry, so is the striving after the other responsible for many of the advances in mathematics.

On the other hand, those physicists who have advocated the theory of relativity see in it a further advance in the long attempt to rightly explain the universe. The whole history of physics, is, to use a somewhat doubtful figure of speech, strewn with the wrecks of discarded theories. One does not have to go back to the middle ages to find amusing reading in the description of these theories, which were seriously entertained and discarded only with the greatest reluctance. But all the arguments of the wise, and all the sophistries of the foolish, could not prevent the abandoning of a theory, if a few stubborn facts were not in agreement with it. Of all the theories worked out by man's ingenuity, no one has seemed more sure of immortality than the one we know as the Newtonian mechanics. But the moment a single fact appears which this system fails to explain, then to the physicist with a conscience this theory is only a makeshift until a better one is devised. Now this better one may not be the relativity mechanics—its opponents are insisting rather loudly that it is not. But in any case, the entire discussion has had one result pleasing alike to the friends and foes of relativity. It has forced upon us a fresh study of the fundamental ideas of physical theory, and will give us without doubt, a more satisfactory foundation for the superstructure which grows more and more elaborate.

It can well happen that scientists, some generations hence, will read of the relativity mechanics with the same amused tolerance which marks our attitude towards, for example, Newton's theory of fits of easy transmission and reflection in his theory of the propagation of light. But whatever theory may be current at that future time, it will owe much to the fact that in the early years of the twentieth century, this same relativity theory was so insistent and plausible, that mathematicians and physicists in sheer desperation were forced either to accept it, or to construct a new theory which shunned its objectionable features. Whether the relativity theory then is to serve as a pattern for the ultimate hypothesis of the universe or whether its end is to illustrate what is to be avoided in the construction of such a hypothesis, is perhaps after all not the important question.

# THE SMALL COLLEGE AND ITS PRESIDENT

BY ONE OF ITS PROFESSORS

THE institution which must here be described merely as "our college" is one of a large class, of which it may be taken as a typical specimen. It is located in a thriving middle-western town of a little over thirty thousand population. It has a faculty of twenty, a student body numbering a little less than five hundred, a campus of ten acres in the heart of the town, seven good buildings, three of which have been built within the past ten years, endowed funds of over half a million dollars, and library and laboratory equipment fairly adequate to present needs. It enjoys what its trustees and some of its faculty regard as the high distinction of a place on the accepted list of the Carnegie Foundation. While in scholarship standards it may rank below some of the smaller colleges of our state, it is superior to others, and certainly does not fall below the average. There is of course the inevitable weak department, filled by an incumbent whose innocuous "Christian character" is his only recommendation. On the other hand, there are strong departments whose work commands outside recognition in the world of scholars, and whose class-room standards provoke wholesome respect on the part of students. Striking an average, it may be said without exaggeration that, measured by the ideals of its teachers, the college stands for a high grade of scholarship, while measured by the results achieved its standard is barely respectable. In fact, there is far too wide a gap between ideals and achievement, between profession and performance, and it shall be in part the purpose of the present article to trace some of the causes of this unfortunate discrepancy.

Many more or less obvious reasons suggest themselves. Insufficient equipment is frequently assigned as the cause of our shortcoming; yet this is a most inadequate excuse. While not all that it ought to be, the equipment of the college is not bad. Great scholars, both in the humanities and the sciences, have been trained on poorer material equipment than ours. Inbreeding may be suggested by the outsider who reads our catalogue and observes that seven teachers out of twenty were trained at the home college. This suggestion is not without weight, for in colleges as in human families inbreeding tends to accentuate the defects, yet a good majority of the faculty were trained in eastern universities, and the third who took their bachelor's degree here have had their courses at higher institutions, with a chance to absorb university methods and ideals. While inbreeding has been anything but a benefit to the college, it would be grossly unfair to hold it responsible for all our shortcomings.

The low salary paid is a more potent cause of failure, and more generally recognized—especially in faculty circles. Married professors are expected to live on salaries ranging from a thousand to fifteen hundred dollars, pay from twenty-five to thirty dollars a month house rent (for houses can not be had in our section of town for less), dress in such fashion as to be be able on occasion to meet the trustees and their friends socially, and contribute to the formal entertainment of the student body four or five times a year. Needless to say, after the satisfaction of these demands nothing remains for the purchase of books, for travel or for study at eastern or European universities. The professor and his family are fortunate if they get through a year without running deeply in debt, and the almost inevitable result of an illness in the family or other unforeseen catastrophe is the starting of a train of evils from which the unfortunate teacher escapes—if he escape at all—only by finding a better paid position in some larger institution. Most of our faculty are so harassed by financial worries that their efficiency as teachers is seriously impaired. Such a condition as this might seem explanation enough of our failure to secure the best results, yet, serious as it is, it is not the fundamental difficulty in our college. It is a symptom rather than a primary cause.

A few courageous professors might so far endanger their popularity as to suggest that the overemphasis placed on athletics has some relation to our failure in realizing our ideals, and in this they would not fall far short of the mark, yet after all the explanation is not entirely satisfying. The overemphasis placed on athletics is in the final analysis but a symptom. The disease from which the college suffers might exist were there no such thing as athletics, and it were unfair to make athletics alone the scapegoat.

The trouble that afflicts our college and other colleges of its class is one that can not be cured by the excision of this or that diseased part. The situation, indeed, does not lend itself kindly to the metaphors of surgery; would we describe it truly we must employ a spiritual metaphor, for it is a rebirth that our college needs, and only by a rebirth can it be saved. The root of the difficulty lies deep in its very constitution. If we would discover why the institution has more or less persistently and systematically fallen short of its recognized duty, and prostituted its own ideals, we must look for the ultimate cause in its fundamental organization.

Ere we depart on this quest, however, let it be clearly understood that the personal ideals of the faculty with regard to scholarship are, for the most part, absolutely irreproachable. We know what sound scholarship is, and we honestly recognize the fact that we are not giving our students all that we ought to give them, though naturally we do not make the fact a subject for general conversation. Neither do we admit that the cause of this condition lies entirely within our own control. The ethical nature of the excuse that "a man must live" may be called in question, but no married man dare question the validity of the corollary that "a man's family must live," nor blame the teacher who, with wife and children dependent on him, places bread and butter ahead of ideals and starvation. On these stern conditions the teacher is often forced to countenance practises which he knows to be fundamentally wrong; and on the same stern conditions he is often forced to assume public responsibility for these same practises. If he protest, he is curtly told that teachers are not wanted who can not loyally support the institution and its policies, and is given the choice of upholding a policy which he knows to be harmful or of tendering his resignation. In short, while they are not allowed any appreciable share in determining the policies of the college, the faculty are forced to pose as the authors of these same policies, and criticism of any one of them is sufficient ground for a charge of "disloyalty" to the institution, and often a threat of dismissal from one's position. In all such matters, the teacher is not a free agent. He acts virtually under duress. The real responsibility for existing conditions must be sought elsewhere.

Above the faculty stands the board of trustees, a self-perpetuating body governing the college from without, sometimes with slight sympathy for the views of those within. The power of the board is absolute; its will is the supreme law of the college. For the most part it is made up of successful business men, few of whom are in agreement with the ideals of the faculty, many of whom indeed are incapable of understanding such ideals. They are keen, enterprising men, who have made money, who are proud of their business, intensely if blindly loyal to the town, and always ready to push its interests in season and out. They are proud of the fact that we have a college here. Its presence advertises us as a literate people, and it attracts new families to the town, thus "making business." While some of them have a rather hazy idea as to what college is for, they are very sure it is a fine thing, and they are willing to work for it, spend time and money for it, and use their utmost endeavors to advertise it effectively. Standards of scholarship are beyond their comprehension, but size appeals to them, for to them size and success are synonymous terms. They are ambitious for a big town and a big college. Whether the latter shall be a center of sound scholarship or merely a degree mill is a question that is not considered; indeed, the very meaning of such a problem is beyond the comprehension of most of them. Theirs is the narrowly commercial point of view, and they are constitutionally incapable of appreciating any problem that can not be expressed in commercial terms.

"M—— is to be asked to resign on account of inefficiency," declared a member of our board of trustees, in the hearing of a friend.

"But I had supposed M—— to be highly efficient," objected the friend. "He has certainly had fine training in his subject, and all who have heard him say that his teaching is splendidly clear and thorough."

"O yes," was the reply, "of course he can teach—we take that for granted—but as a *booster* the man is a flat failure. He never gets out and does a thing for the college—just keeps himself shut up in his laboratory all the time. For all the good he does he might just as well not be here."

Between the faculty, with its ideal of scholarship, and the trustees with their ideal of commercialism, stands the president of the college. Employed by the trustees as executive head of the institution, he has been given great power and broad discretion. In all matters touching the internal affairs of the college he is the confidential adviser of the board, and his advice is seldom disregarded. The board have placed in his hands the right of employing and discharging teachers at will, and without assigned cause. While certain powers are supposed to belong to the faculty, the president may not only veto, but may by executive order reverse its decisions, and in such cases his decision is final. It is true that cases of this sort may be appealed to the trustees, but it is an axiom of the trustees that, so long as they retain a president, he is to be supported in all that he does. As a practical proposition, therefore, in case of any disagreement between faculty and executive, the faculty enjoy only so much authority as the president may choose to allow them, and if he sees fit to overrule them completely they have no recourse. The president is in fact an autocrat, and the college policy is largely the reflection of his individual will.

It must not be supposed however that the board of trustees is a mere negative quantity, without opinions as to the conduct of the institution. The president's opinion is law, but the president's opinion is likely to be the reflection of the opinions of his more influential trustees. He is the creature of the trustees and depends upon them for his office. Were his views to take color unconsciously from those of any other man or body of men, one would expect that it would be the trustees whose opinions would determine his. His faculty have no means of asserting themselves, and are, accordingly, not in a position to command his respect. In the organization of the college they have been deprived of all real authority. They stand powerless before the president, as he would stand powerless before the trustees were there to be a conflict of authority between them. Naturally his views of college policy are modeled after those of the men who control him rather than those of the men and women who are so abjectly under his control. He comes quite naturally to attach too high a value to the commercialistic factor in the college problem, because that is the factor that appeals to his trustees. He discredits the views of his faculty whenever they conflict with the prevailing views of the trustees, even when such subjects as academic standards are concerned, in which it must be supposed that the faculty are experts and the trustees are not. There is, therefore, to-day a broad and ever-widening breach between president and faculty in our college. Socially the best of feeling exists. Officially there is a lack of understanding between the teaching and administrative ends of the institution.

The fact that the president is not himself a teacher tends to widen this breach between his faculty and himself. However much pressure might be brought to bear upon an executive by a commercialistic board, it is hard to believe that any man who had himself occupied a chair of instruction could, as president, forget to take account of the dangers that beset the scholastic ideals of the college at every turn. Nobody who has not served for some years as a college teacher can have any adequate realization of these dangers. Only the teacher knows the strength of the pressure that is brought to bear day after day, month after month, and year after year, for the scaling down of the passing standard, the destruction of effective discipline, the currying of favor by the introduction of "snap" courses, and the virtual abrogation of all rules in favor of successful athletes. Athletics indeed is the most frequent excuse urged in extenuation of the breaking down of an effective standard of work, and the statement that a boy is "representing the college" is apparently regarded by president, trustees and public at large as ample warrant for excusing him from any decent pretence of work and presenting him with an A or B grade merely as a compliment to his prowess as college "representative." Athletics is not the only occasion, however, for the manifestation of this spirit, and more than one professor has found himself in serious difficulty because of his failure to show a delicate sense of diplomacy in discriminating among the students who have failed in his department. Those who have trained themselves to see these things from the angle of the business office understand that such matters must be settled with due regard for the commercial rating of the student's family. "The boy's people are wealthy, and have always been friendly to the college" is regarded as valid excuse for undue leniency on such occasions. Against such insidiously demoralizing influences as these the more conscientious and discerning of the faculty struggle as best they can, and the fruit of their effort is seen in the fact that during the past half decade there has been a stiffening of class-room standards throughout the college. Yet the condition is still far from what it ought to be, and it is no exaggeration to say that such improvement as has come has been brought about in spite of the president and not because of him. While acutely anxious to safeguard our popularity he has apparently been unaware of the fact that standards of college work also need safeguarding, and that to this end eternal vigilance is necessary. Had he ever been a college teacher, it would have been impossible for him to overlook this very obvious fact. It is to his ignorance of the college, as seen from the teacher's side, that we must attribute his failure in this respect. Before becoming a college president he was a minister, as were the presidents of most of the colleges of our state. Out of our thirty-one small colleges only nine have chosen laymen to the presidency.

Most of these colleges are, of course, still under denominational control, and while such is not the case with our college, tradition demands that a clergyman fill the presidential chair. This tradition is doubtless a survival from the days when ours also was a strictly denominational college. We still have a large clientéle in the state who cherish the fear that the choosing of a layman for the presidency would be the last step in the secularization, and therefore the demoralization of the college, that it would thenceforth lose its character as a Christian college and would become "Godless" in its tendencies. Just how sectarianism contributes to the development of Christian character is not explained, nor is it made satisfactorily clear in what way a wise and well-trained teacher would fall short as an executive. Sooner or later this ministerial tradition must be dispensed with, for we must eventually realize that the only truly competent executive is the one who has "been through the mill" and has risen to the presidency from the ranks of college teachers; nor will the character of the college as a Christian institution suffer in the least by the appointment of such a man. Rather is it likely that our Christianity may take on a somewhat deeper tone, and find its vent in somewhat more practical manifestations. There may come to be less preaching and more performance, less self-conscious talk about the state of one's soul, and at the same time less cheating in examinations; for present experience indicates that religion of the current type and dishonesty of a conventional sort are not at all incompatible. Our inherited brand of Christianity is sincere but narrow, issuing at best in a personal righteousness that fails to take account of the broader social responsibilities confronting the present age. It is to be hoped that our college will ere long cast aside its theological leading strings and grow into something broader and better than its present pseudo-sectarianism.

Undoubtedly one of the worst effects of our president's failure to recognize scholarship as our goal is its demoralizing effect on members of the faculty. Left to themselves, there is no doubt that our teachers would pursue scholarship as the end and aim of their professional efforts. But as things stand at present, those who engage in this lofty pursuit are neither encouraged nor appreciated. Our president wants "rustlers"—men who are ready at a day's notice to leave their classes and go out on a financial campaign or a student canvass, men who are continually in the lime-light, attending committee meetings, speaking to student gatherings, devising changes in the man-millinery which is the outward and visible sign of our high calling, addressing questionnaires to the rest of the faculty on all sorts of unimportant topics, tacking up notices in the halls, rushing officiously from place to place, and making themselves generally as conspicuous as possible. Our president is a fanatic on the subject of "efficiency," by which term he means merely "activity." He has not yet discovered that much of this activity is about as fruitful as the activity of a kitten chasing its tail. His ideal —copied from that of his trustees—is commercial and material. Fruitful or not, the activity must be outward and evident, lending itself readily to advertising purposes; and for quiet unremitting intellectual labor, issuing in broader learning, deeper culture and better teaching, he has scant appreciation. What wonder that more than one teacher has become a mere promoter, letting his department deteriorate most woefully while he assists in the "broader" task of "running the college." Such is the sure road to presidential favor. Were our president himself a college teacher, viewing matters from the teacher's angle, this condition could not exist; but he is a promoter, employed by a group of promoters to advertise this educational undertaking of ours, and he sees the college from the promoter's viewpoint.

Yet even supposing the college headed by an experienced professor, with breadth enough to appreciate the needs of all the various departments, financial ability enough to make a good business manager, and courage enough to fight if necessary for the integrity of collegiate standards; could it under such conditions run smoothly and effectively? Probably not! Probably the man does not live who could fully satisfy the conflicting demands of faculty, trustees, student body and general public. It is time indeed that the student body and general public were left out of account in the consideration of this problem. Current opinion to the contrary notwithstanding, the college that will abandon the policy of inflation will be content with a small student body strictly selected from the available output of the high schools, and will make no effort to harvest as large a crop of freshman as possible, will soon have more students knocking at its doors than it can possibly accommodate. The annual scramble for students is a most undignified performance. It gives the public a false impression of the college, and leaves in the mind of the freshman a most exaggerated idea of his own indispensability in the educational scheme of things. Our college, like others, has cheapened itself in this respect. It is time that it learned its own worth, and realized that it is to be sought rather than to seek. But, leaving student body and public out of account, it may be asked whether our model college president could satisfy at the same time the ideals of the faculty and the ambitions of the trustees. Probably not. It was said at the outset that the disease from which our college suffers is constitutional, and that what it needs is a rebirth, that is to say, a reorganization along radically new lines. To vary the figure, let us say that the old educational machinery was awkward and poorly constructed in the first place, it never worked well, and with the changing demands of the times it works more and more poorly. We in America, inventive enough along mechanical lines, have been strangely uninventive in the organization of our educational institutions. Early in our history there grew up a form of college organization, adequate enough for its day, but fraught with potentialities of serious danger for the future. The president, in that early time, although usually a clergyman, was a teacher also, and met classes like the rest of the faculty. His was not then a position of great power. He was *primus inter pares*—the senior member of the faculty and the presiding officer in its meetings—not the Czar that he has since become. The American college was poor in those days, and its scanty funds were held in trust by a body of men who, that they might be impersonal and disinterested, were chosen from outside the college. As the college grew in wealth this group of trustees grew in importance, and gradually assumed not simply the investment of college funds, but the actual management of the college itself. Needing a representative within the college, they naturally chose the president, conferring on him autocratic authority, and correspondingly curtailing the power of the faculty. Thus grew up, gradually, a makeshift system of college government that could hardly be worse. The wonder is not that it works so poorly; the wonder is that it works at all; yet for many generations this system has been reduplicated all over the United States with scarcely a thought of the possibility of an improvement. Our college is merely one of the many that have copied this viciously undemocratic model, incorporating its worst features into their charters.

Trustees, president and faculty alike suffer from this bad condition of things. The faculty, being debarred from the exercise of their natural functions, become firebrands of discontent, or relapse in fatalistic apathy, or become parasitic sycophants fawning on president and trustees for such crumbs of favor as may now and then be thrown in their direction. In general they feel keenly that something is amiss, but fail to analyze the situation and locate the trouble. Yet the situation is not difficult of analysis. The key to it lies in the fact that the college is governed by men who lack the technical experience necessary to govern it well, and the faculty, who possess this technical experience, are barred from any effective share in its management.

The president makes a sincere effort to make a fair and equitable adjustment of the budget to the needs of the departments, but he fails, and that for a number of reasons. In the first place, he lacks the technical knowledge necessary to an understanding of the needs of the departments. In the second place, he is under the influence of the trustees with their passion for expansion and inflation; and he is continually trying to make a big showing by putting the funds that should go to the strengthening of existing departments into the creation of new ones, or into advertising. Thus the older departments are deprived of needed equipment (the students of course being the ultimate sufferers) and salaries are kept below the efficiency level. In the third place he fails because he enjoys too large a measure of irresponsible power. It is the fashion nowadays to compare the college to an industrial plant, and the president to a factory superintendent. But there is this difference: The superintendent of the plow factory in our town can make a plow. He knows the details of construction in every department of his factory, has actually done the work himself, and can do it to-day if necessary better than any of his men. On the other hand, the college president knows far less about any given subject than does the professor who is set to teach that subject. He has no first-hand knowledge of the needs of any department. The factory superintendent is an expert directing the efforts of those less skilled than himself. The college president is a tyro directing a body of experts. His very ignorance makes it unsafe to place the power of official life and death in his hands.

As for the trustees, there can be no doubt that they are earnestly loyal to the college and devoted to its interests, and their own careers attest them good business men; yet the business management of our college is notoriously poor. College property that might have been made to return an excellent rental has been allowed to lie unproductive for years, and finally sold off bit by bit to pay running expenses; debt has been recklessly incurred; and there has never been any settled or consistent financial policy. The board, indeed, is too big a body to work well. It consists of twenty-four members when five would be a much more effective body. But the principal difficulty lies in the fact that the time of board meetings is taken up in the consideration of a multitude of problems all of which belong by right to the province of the faculty, and too little attention is given to the matter of finance. Briefly stated, our board fails because it does not concentrate its time and energy exclusively on the one thing for which it exists, namely, the providing of ways and means.

It is easier to criticize an existing system than to work out the details of a new and better one; yet the diagnosis just given suggests the remedy. The number of trustees should be reduced to five or six—of whom the president of the college might well be one *ex officio*—and their activities should be limited strictly to the investment of college funds, the raising of new funds, and the collection of rents and interest. After setting aside enough of the latter to meet overhead charges in the way of repairs, care of buildings and grounds, etc., they should place the balance with the college treasurer to be paid over to the various departments in accordance with a budget to be worked out by the faculty. The president should be the chairman of the faculty and its public representative, and should have a veto on all acts of the faculty—a veto which the faculty might override by a two thirds vote. The faculty should have complete and absolute jurisdiction over all the internal affairs of the college, and over the budget, subject only to the veto of the president; they should elect all teachers, subject to the approval of the president, and should when occasion demands elect the president, subject to the approval of the trustees. Finally, no member of the teaching force should be liable to discharge except after the filing of formal charges of impeachment, and a trial before the entire faculty, and the concurrence of the president and two thirds of the faculty in sustaining the charges alleged. Some such system as this, arranged to place every responsibility on the shoulders of those best equipped to meet it, and safeguarding against the misuse of power by an adequate system of checks and balances, would eliminate most of the evils incident to the present system of American college organization.

It may be objected that the budget would be a fruitful source of faculty discord. Some discord might, indeed, exist, but it is a fair question whether discord is not preferable to intrigue. Were it not better for a professor to go into faculty meeting and fight for the weal of his department openly, than to enter a private office and lobby for it secretly. In colleges, as in politics, publicity is a strong incentive to decency. The present system is one of secrecy, intrigue and deceit. The president, who holds the key to the situation, lacks the necessary special knowledge of the departments and their needs, and the securing of funds by the various professors becomes largely a competitive test in the matter of sycophancy. It were better to have all such matters threshed out in open meeting, with the data in question before the faculty. In the end its decisions would be fair and just. Here, as elsewhere, the principle of democracy will work if given half a chance.

Finally, to the charge that the proposition here offered is too radical, let us make answer by advising all doubters to study carefully the organization of the colleges of Oxford and the universities of Germany.

When one college shall have adopted the plan here suggested of transferring to the faculty the functions that are rightfully and naturally theirs, and limiting both trustees and president to their natural functions, a new and brighter era will have begun in the history of American education. The standard of collegiate instruction will at once rise many degrees, the college teacher will become a more useful member of society, as will also the college president, harmony instead of discord will reign among the three branches of the college government, and all three will be in a position to make a united and effective attack on the educational problems that are calling for solution. For when one institution shall have changed, others will soon follow, and in time our entire college system will re-form itself in accordance with the dictates of true wisdom, and along the lines of true democracy.

# LABOR AND CAPITAL

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THE manual worker is not left in ignorance respecting his rights, his wrongs and his importance. In season and out of season he is taught that the world owes every man a living and that he should receive wages enough to support his family according to the American standard; that his labor makes value and that his share of the profits is withheld; that capital, all-powerful, is consumed with passion to enslave helpless labor; that he can secure his rights only by compulsion, since the interests of capital are antagonistic to those of labor. These matters deserve consideration.

The world, that is, the community, owes no man a living; it did not bring any man into existence and it is under no obligation to support the children of heedless parents. One must emphasize this truism, because there is a rapidly growing tendency to believe that poverty and vice are due to the rapacity of employers and to insist on the responsibility of the community, *en masse,* for continuance of the evil conditions. During a so-called investigation by a commission of the Illinois Senate, an official of the Illinois Steel Company was asked to tell what he regarded as a fair living wage for a man with a wife and daughter. At a hearing before a Massachusetts commission it was shown that the wages paid are so small that one employee, in order to support himself, his wife and their eight children, was compelled to do outside work—and the heartless corporation was duly flayed in headlines. But it must be evident to any thoughtful man that wife and children can not be considered in connection with the relations of wage-earner and wage-payer. The only question concerns the worth of the man's services. Introduction of other matters would so increase the uncertainty of business affairs as to make them little better than a lottery. If a man's services are not worth enough to secure wages which would support a family, he should not marry. He may not complain because the community is unwilling to have him gratify his desires at its expense.

The wage in shops and factories is said to be so small that women are driven to prostitution; one is told that, in each year, 200,000 women in our land are compelled to sell their bodies to procure the necessaries of life, and that each year sees 700,000 children perish because their parents have insufficient nourishment. But the voices, which rise in bitter outcry against this awful condition, do not rise in protest against encouragement of unrestricted reproduction among the wretched or against the wide open door which increases the population annually by a net half million of, in great part, poverty-stricken immigrants—and this in face of the fact that our country is no longer able to provide work for those already here. If it be true that the alleged number of children die because they or their parents have insufficient nourishment, one must concede that their deaths are a blessing to themselves and to the community. Such children should not have been born. But the assertions are *a priori,* they can not be proved and are closely related to the other assertion that poverty is *the* cause, not merely *a* cause of crime. The statement of an abandoned woman before a State Commission is accepted as final, despite the counter assertion of the associated social workers, whose close relations with the impoverished classes should make their statements authoritative. But the slanderous statement is spread broadcast and wage-earning women are viewed with suspicion.

It may well be that not a low wage, but a wage too low to gratify vanity or the desire for luxuries, may be the determining cause in a great proportion of cases. Sexual desire is the strongest natural appetite in every normal young man or woman. If there be a deep-seated moral sense, the wage will make no difference. If there be no moral sense, the wage is unimportant. So long as the chief deterrent from gratification of the desire is the fear of inconvenience and social disgrace, yielding to temptation will be dependent on the danger of exposure. Unquestionably, the majority of fallen women come from the poorer classes, because those classes are by far the most numerous; but a very considerable proportion have come from among those whose wages are far from low, while the record of divorce courts make very clear that even the possession of wealth can not prevent women from straying. This question of morals in women employees answers well as a slogan in attacks upon wage-payers, but it appears to sink into insignificance when it involves the rights of wage-earners as against the wage-payer. A telegram from Everett, Washington, dated October 23, of last year and published in the New York papers, gives the illustration. The manager of a telephone company, appearing before the State Industrial Commission, held that employers should weed out from their service all immoral girls and women. But two women members of the commission maintained that employers should not concern themselves about the morality or immorality of women employees, provided these perform their tasks efficiently; these commissioners insisted that the employer has no right to exercise any control over the conduct of employees outside of working hours.

The demand that all should be able to live according to the "American" standard, whatever that may mean, is coupled with the assertion that wages have not kept pace with the increased cost of living. Tables of comparative prices are published in the daily papers, which prove that the cost of food has increased incredibly within a decade or two. It is well understood that one can prove almost anything by means of statistics and these tables are illustrative. Some of them are as absurd as would be tables to prove increase in cost of living by comparing the price of diaphanous calico in 1858 with that of the finest cambric muslin in 1913. The writer has lived in New York city during almost three quarters of a century and he knows that, whatever may be the conditions elsewhere, prices of the essential articles of food, with few exceptions, show comparatively little increase during the last fifty years, while some show a marvelous decrease—material of the same quality being compared throughout. Beef, such as nearly all New Yorkers ate sixty years ago, can be purchased at hundreds of large shops at barely 20 per cent. higher price; flour, grade for grade, has not risen in price, while the great fluctuations in price of the olden time are unknown—in 1854 or 1855 the writer paid twelve dollars for a barrel of family flour for his father; eggs, grade for grade, are, thanks to cold storage, little higher during the winter months than they were many years ago; while refined sugar costs to-day little more than was charged for a light brown sugar in 1858. Butter and hog products have increased in cost and are likely to continue increasing until ruled off the list of foods. The growth of urban population has destroyed the butter industry, as sale of milk is more profitable and less burdensome. In former times, when corn was worth only a few cents per bushel, western farmers had their choice between using it as fuel or converting it into pork. But corn is worth now from 50 to 70 cents per bushel, according to the crop, and it can not be converted into pork except at a loss. Pork will disappear as a food staple and butter will be replaced by the more wholesome oleomargarine products. Within our large cities, an anomalous condition exists in the price of vegetables. Wholesale prices have not increased, indeed in many cases, they have decreased greatly; yet because of archaic methods of distribution, the retail cost is greater. But this does not concern the general question.

The stability of prices of the food staples, in spite of increasing demand, is due to several causes, of which only three need be noted; the consolidation of continuous transportation lines, which has made possible the extraordinary low freight rates in this country; the consolidation and localization of manufacturing interests, which has increased available capital and has led to introduction of improved methods; the ingenuity of inventors, which has made unnecessary a vast quantity of unskilled, even of skilled labor. Our flour is from Dakota wheat ground in Minneapolis and our beef is from western cattle slaughtered in Chicago, yet the prices are, at most, little higher than those paid sixty years ago for flour brought by water from Rochester and Richmond, or for beef from Ohio and New York.

But in some other directions, where the inventor's work has not kept pace with expansion or where trade-union influence has prevented full utilization, the effect of increased wages is only too manifest; the mechanic has himself to blame for the untoward condition. Compared with 1858, a day's work means fewer hours and greatly increased wages. One illustration suffices. Building is much more expensive when bricklayers receive about 6 dollars for 8 hours of work than it was when they received 2 dollars for 10 hours' work. The increased cost of living in large cities is due very largely to increased wages for decreased hours of work. If one doubt this relation between wages and prices, he needs only comparison of the cost of pig iron and of ready made clothing in 1897 and 1901, the difference being due almost wholly to wage-increase.

The cost of living has increased out of proportion to the wages, but only because the mode of living has changed and the requirements are greater. The clothing of fifty years ago would not satisfy the people of our day. The clerk must ape the man who has twice his wage. The workingman demands luxuries for his table, which the well-to-do man of sixty years ago never thought of buying. One is asked indignantly, Has not the poor man a right to these things? Certainly, if he can afford to pay for them, just as every man has a right to an automobile and chauffeur, if he can afford to pay for them; but no man, rich or poor, has the right to expend so much of his income on things, not necessary, that, when times of depression come, he will have nothing left and must become a burden to the more provident members of the community. The complaint is the same throughout the scale; it is not confined to the "poor" but is common to all; the man with two dollars a day is embittered as he considers the luxury of the man with five dollars; the man with ten thousand dollars a year is unhappy because, in his limited condition, he can not make so grand a show as does the man with twice or five times as much. It is impossible ever to reach the "living wage," because desires increase with the income and poverty is always present. Men's minds dwell almost wholly on what they have not; too few are willing to recognize the abundant blessings which they possess.

Labor certainly creates value and it is entitled to a generous reward; but this doctrine, as defined by labor unions, is not exact, since they lay the chief emphasis on manual labor. Yet they do not ignore the superiority of mental labor. The plasterer, whose work requires much natural as well as acquired skill, would be indignant at a suggestion that a hod-carrier should receive wages equal to his own. Unskilled labor is merely animated machinery for rough work and adds very little value to the final product. It is utilized because abundant and low in price; as soon as it demands an excessive wage, it is displaced by machinery. Skilled labor, combining muscular and mental effort, increases the value in proportion to the mental expenditure; but mental labor, involving no muscular exertion, adds most of all, it is the coordinating, creating power without which the others would be helpless. One E. H. Harriman is of more lasting service to a nation than would be one million of unskilled laborers; without a Harriman they would be a menace. The complaint by the lower grades of workers against the reward paid to those in the higher grades is as absurd as would be a complaint by raw Muscovado sugar because refined sugar brings a higher price.

The asserted power of capital is little better than a nightmare. There can be no federation of capital comparable with the existing federation of labor. The acquirement of capital, that is the saving of a part of one's income or wages, demands much personal independence and self-control, an individuality which makes impossible such slave-like obedience as prevails in labor unions. A monopoly, except through ownership of patents, can not exist in this land. The field for capital is wide open and if any man or corporation prove that a business is profitable, competitors appear quickly, demanding a share. The dwindling proportion of trade controlled by the United States Steel Company, by the American Sugar Refining Company as well as the bitter competition between manufacturers of tobacco amply confirm this statement. Capital constantly combines against capital. The fruit raisers of California unite against the transportation companies to secure unremunerative freight rates, as though the railroads are to blame because the orange and lemon groves are 4,000 miles from the Atlantic seaboard. The tobacco farmers of Kentucky combine against the manufacturers to increase the price of raw materials and enforce their mandates after the most approved trade-union methods; makers of heavy, bulky goods, in order to secure space cheaply, put their factories in out of the way places, but they denounce the transportation companies as robbers because these desire a fair remuneration for special construction and service. The sluggish capitalist, as shopkeeper or manufacturer, rails against his energetic competitor and finds prompt encouragement from politicians, who would tax the efficient man out of business and would leave the community at the mercy of inefficient managers, wedded to antique and expensive methods of production.

On the other hand, combination of labor is no mere possibility; it is an accomplished fact. Labor unions, though controlling only a small proportion of the hand-workers, have succeeded by compact organization in terrorizing office seekers and office lovers, so that legislative bodies grant their demands with little apparent reluctance—and this in spite of the fact that, in some portions of the country, the membership of great unions is largely alien. Compensation laws are enacted freely and are wholly against the "capitalist," who pays the wages to workingmen and the construction placed upon these laws almost invariably favors the employee. Such laws, unquestionably, have solid foundation in justice. An employer must have care for his servants who, too often, are helpless against careless fellow-workers. The employer should enforce discipline and should discharge at once the negligent, incompetent or disobedient employee as a source of danger to persons as well as to property. If he retain such employees, he is himself negligent and should pay the full penalty in case of disaster. No one may complain against this; it is absolutely just. But at once the question arises, who is the employer? The prevailing impression is that those who pay the wages are the employers and compensation laws accord with that belief. The conception was correct enough fifty years ago, but in most industries it is very far from correct now.

In what may be termed unionized industries, the wage-payer is an employer in only a very limited sense. The trade union is the employer, the only employer. The chief strife between capital and the unions concerns this one matter. The many recent strikes in non-unionized industries were not to secure higher wages or shorter hours, but to secure recognition of the unions. Betterment of the workmen's conditions was always mentioned, but that was a secondary matter. The result of such recognition has always been transfer of control from the wage-payer to the union officials. The owners of industrial concerns assume all risks while others control the workers and the methods. Railroads are denounced in congress, in legislatures and in the press because they invite disaster by retaining incompetent servants. Mining and manufacturing companies receive similar treatment. Yet nothing could be more unreasonable. Commercial enterprises are undertaken to secure a fair return on the investment and competition is so severe that the margin of profit is narrow. Owners and managers have no desire to invite disaster and to reduce dividends; but they are helpless in unionized industries. The unions permit employment of only their own members; they determine the rate of wages, the hours of work, the manner of working and, in some cases, even the materials to be used. They demand oversight of discipline and the right to decide whether or not an employee should be dismissed. A superintendent, determined that men must give honest service for the wages received, is denounced as tyrannical and his removal is called for with a strike as the penalty for refusal. In all essential matters, the trade union is the employer, with power to stop work or to begin it again. It regards itself as actual owner of the property and the owner of record is to be tolerated only so long as he obeys the rules. It justifies seizure of the property during a strike; it justifies violence, destruction of property, assassination and resistance to officers of the law in case its demands are refused; it denounces as murderers the men who defend their property against an attacking mob; and it proclaims that its crimes are political, not moral, because the strife is a warfare for human rights.

Labor unions should be incorporated that they may be made responsible as the real employers, as dealers in human labor. Under existing conditions, agreements can be enforced against the wage-payers, but not against unions. When the law has recognized that the union is the employer, disasters on railroads, in factories and in mines will be reduced to the minimum. Reckless engineers, careless switchmen and negligent shopmen will find little mercy at the hands of union officers; miners will see to it that props are put in place and that covers are not removed from lamps; incompetent workmen will be weeded out from the factories and the loss through defective wares will be small. Leaders will not be too earnest in breeding discontent or in urging strikes on frivolous grounds. But those who guide union affairs oppose incorporation; that means stability in conditions, steady work for workmen, no waste of savings during enforced idleness and consequently the destruction of the leaders.

The state, under such conditions, would be compelled to distinguish sharply the several duties of the wage-payer and the employer. Serious responsibilities would still rest upon the owners of property in which men are employed. There would remain to them the duty of protecting workers against accidents due to imperfect machinery or appliances. Yet even here the complexity would remain and strife would not cease. It would appear that the only solution of the problem may be in placing control wholly in the hand of wage-payers, as in non-unionized industries.

The professions of the trade unions are at variance with their practise. They pretend that they are warring for human rights, but they deny the natural right of all men to work and endeavor to limit it to their own members; they deny the right to earn, by fixing a common wage for competent and incompetent, for faithful and unfaithful men alike; they cry for uplift of the working classes, but they resist all efforts to close the cleft between "classes" and "masses," insisting that it remain a bridgeless chasm; an "employer" of labor can not gain or retain membership in a union, because the several interests of labor and capital are antagonistic. When Sir Christopher Furniss offered to his striking workmen the opportunity to purchase his shipbuilding plant on easy terms or to become partners on a profit-sharing basis, the union officials rejected both proposals on the grounds that acceptance of the first would create only another class of capitalists and that acceptance of the second would develop a class of selfish workmen, who would not try to help the "under dog." The plan of the United States Steel Company to offer stock below market rate to the more efficient workmen was denounced as a base trick to bind men to their employers by selfish interest. Workingmen everywhere are taught to look with suspicion on all efforts of employers to encourage thrift. It is impossible to believe that the heads of labor unions have at heart the interests even of their own followers. Enforced idleness during frivolous or sympathetic strikes, lodge dues, strike assessments, testimonials and other contrivances, equally ingenious and successful, certainly prevent too rapid accumulation of savings and remove all danger that the men will become financially independent of their owners. Yet these owners never weary of picturing to the workingman the miseries of his condition; one might imagine that medieval conditions exist everywhere, whereas they exist only among the peons of the trade unions. Cicero was unable to understand how one soothsayer could look in the face of another without laughing. He would be more puzzled to-day if he should hear a labor leader telling his serfs that capital has made it impossible for a poor man to rise above his caste—and this in New York city, where a great proportion of the wealthy men have risen from poverty and a very great part of the real estate is controlled by men who reached this country almost penniless less than 30 years ago. The savings bank deposits in the anthracite region and in the copper region of Michigan prove that the "awful misery" did not exist when the men were at work. These savings have been referred to boastfully as the "backbone of the strike."

The selfishness of unions proves the hollowness of their pretence that the warfare is for the rights of humanity. Not only do they attempt to prevent all except their own members from gaining a livelihood, but they also do not hesitate to incommode the whole community, rich and poor alike, in order to hasten success of a strike. It matters not how insignificant the matter at issue may be, the fact that it is an issue makes it so important that destruction of the community would be preferable to defeat of the organized minority. One need not occupy space by detailed illustration. The numerous trolley strikes, ordered at hours when most inconvenience and suffering may be caused; the recent strike of railway engineers in northern England, whereby a great region was threatened with starvation, because the company had suspended a tippling engineer; the recent strike vote on a New England road because the company insisted that fitness should be considered in assigning engineers to important trains; and the strike for similar reasons on the Southern Pacific road suffice. The list might be increased indefinitely, showing indifference to interests of workers who do not belong to the union army—even of those who do belong to that army, but not to the disturbing regiment. The boast, "for the rights of humanity" means for the right of union humanity. Mr. John Mitchell is reported to have said at a convention of labor leaders, that the condition of wages is better than ever before, but still he would ask for more. If a 25 per cent. advance were granted, he would demand yet more. If an eight-hour day were secured for all, he would struggle for a seven-hour day. All this, of course, for unionists. Members of unions are said to number about 2,000,000 in this country; they are to thrive at the expense of the vast majority, who must pay them high wage for a short day. Many are puzzled to explain why trade union workers should have a short day when almost all others have a long day, although the labor in most of the trades, which are unionized, is less exhausting; but the explanation is simple; the union, like the highwayman, possesses power to enforce its demands. There is no laborer save the "horny-handed son of toil"; others exist to be exploited in his strife against the natural law of work.

Labor unions and their defenders justify the use of violence because without it they could not succeed. The assumptions are that labor and society are at war, that the interests are irreconcilable and that demands by labor leaders are always just. McNamara at Los Angeles saw no moral turpitude in arson and murder, because he fought for a principle. The unions evidently agreed with him for they expended a vast sum in his defense. Thirty-eight men were convicted in Indianapolis of complicity in his and similar crimes, but the union approved their work and re-elected the convicts to their offices. The daily papers report almost daily cases of murder and arson in localities where strikes have been ordered. Labor unions defy the law but are ever ready to demand its protection; their principles are no better than those of the India Thugs, who practised robbery and murder in the name of the goddess Cali.

The cruel disregard of other's rights is not born of folly; the union men know that a great part of the community sympathizes with them. Propagation of their doctrines has not been ineffective. There is a general disaffection against those who have achieved success; it matters not what kind of success, the thing itself is a crime. The brutal rapacity of "capitalists" is a welcome theme and no charge is too absurd to be accepted as true. If it be proved false, retraction is made grudgingly with the reflection that the old wolf has escaped this time, but he ought to have been hanged long ago. It is still an article of faith in many quarters, even outside of those inhabited by peoples alien to our mode of thought and to our language, that the panic of 1907 was contrived deliberately by capitalists of New York city, the ground for the belief being, apparently, that they can bring on a panic if they choose. The worst charge that can be brought against a man is that he is rich or against a combination of men, that it is a corporation. The most serious feature of present conditions is the blind, inconsiderate hostility to "capital" manifested by legislators, who are clearly ignorant of what the term means. There is reason to suppose that the average business man is no more and no less honest than the average of mankind or of labor leaders; but his lack of integrity is less dangerous than that of a labor leader, because his interest requires that the community be prosperous, whereas the labor leader is indifferent to the community's interests; he is concerned only with his *imperium in imperio.*

The propaganda has been so successful that in every contest between wage-payers and unions the popular presumption is against the former. During trolley strikes, indignant sufferers vent their wrath upon the company which refuses to grant the petty demands; when trains or trolley-cars must be withdrawn because of half-hearted protection by the authorities, a cry for repeal of the franchise is raised. A public utility corporation seems to have no rights which the law is bound to respect; it may not share in the general prosperity; even high officials appear to think it virtuous to over-reach such corporations. And all this because they have received certain privileges from the state, which are of inestimable value, while the services rendered in return are wholly undeserving of consideration. The popular antipathy to "big business" has become almost a mania and a great part of the community trembles at the concentration of the "money power" in the hands of a few score of men—though why there should be such terror on account of concentration of the money power and no terror because of concentration of the labor power in still fewer hands is difficult to understand. Laws against mere bigness have been enacted as readily as though it were a crime like burglary. The case of the Harvester Company is in point. The Missouri judge recognized that the whole course of that company had been commendable and to the advantage of the community, but, under the statute, he was compelled to impose a heavy fine because, by acquiring practical control of the market, it had become able, if so disposed, to inflict injury. That the American Sugar Refining Company has reduced the cost of sugar by 50 per cent. and that it is satisfied with a gross profit of less than half a cent per pound is nothing; the concern is too big. That for every dollar of gain secured by the Standard Oil Company the community has gained many hundreds through the reduction of illuminating oil to one sixth of the price 40 years ago is nothing; that most of the profit gained by that company has come from utilization of what was regarded burdensome waste material is nothing; the company is too big and makes too much money. The stupendous service rendered to the country by the United States Steel Company by prevention of panics and depressions is nothing; it is too big. Attacks on these organizations by government officials win great applause, in spite of the fact that so-called "trust-made" products are almost the only ones which have decreased in price—although the great companies pay high wages and their workmen have steady work, because trade unions can not gain a foothold to impoverish the wage-earner by strikes and compulsory idleness.

The confusion of ideas respecting the relations of labor and capital is perplexing; the terms are not used in the ordinary sense throughout. Combinations of transportation or manufacturing companies are taken to be, in themselves, evidence of conspiracy in restraint of trade; but positive conspiracy in restraint of trade by organizations, avowedly formed for that purpose, is highly proper on the part of agriculturists and labor men; and the authorities must not interfere. Tobacco raisers in Kentucky may combine to secure higher prices for their products and "night riders" may burn the property of those who refuse to join the conspiracy; labor combinations may struggle to destroy competition with their members, may attack, even murder those who refuse to submit to their dictation, and they may destroy the property of those from whom they have been receiving wages; cotton planters in the south may combine to force higher prices for their commodity, even though they resort to violence that competition may be prevented. All such combinations are but exercise of natural rights, with which the law should not interfere. But when manufacturers or transportation companies combine to stop waste or ruinous folly in competition, they must be checked at once as threatening the community's prosperity.

This confusion of ideas is not confined to the "unthinking"; it is found among those whose prominence in public affairs is a fair presumption in favor of belief that they are thinking men. Organizations engaged in great industries have retained representatives at Washington as well as at other capitals in order to protect their interests by opposing injurious legislation. There is no doubt that they have endeavored to compass the defeat of politicians who opposed them and they have expended large sums of money in printing and postage to influence public opinion—they do not "admit" this: on the contrary, they assert it unhesitatingly and justify their course. Newspapers and politicians profess to be shocked by such avowals and it is said that some members of an investigating committee were stunned by the shamelessness of the "capitalists." One's sympathy goes out to those innocents. Yet such efforts are within the rights, indeed are within the duties of every citizen; certainly they are in every sense as proper for "capitalists" as is the conduct of taxpayers' associations, philanthropists or labor unions when they do the same thing. Nevertheless, it would appear that the labor unions were aiding the uplift of humanity when they endeavored to prevent reelection of Mr. Cannon, who had treated them with contempt, whereas the National Manufacturers' Association was endangering the Republic's stability by its efforts in his behalf. It was thought to be pernicious lobbying when the Hawaiian planters struggled for retention of tariff on raw sugar while the Federal Sugar Company was thought deserving of credit because it sought removal of that tariff; among the many protests against lobbies few were heard against the labor lobby, which has been denounced as the most insidious of all. Senator Lea summed up the matter clearly when he stated that when a visitor disagrees with a congressman's opinions, he is a lobbyist; if he agree, he is an expert. Those who have followed closely the discussions in congress during recent years must be convinced that too many members are afflicted with the omniscience of ignorance and that they are sadly in need of information on nearly all subjects except the local interests of their districts.

But one may ask, how can such conditions exist and how is it possible that men bearing the responsibility of public office can yield to influences so injurious to the common weal? The writer is no mind-reader; it is not for him to impute improper motives in any case. He may note only the facts which are familiar to all; others may make such inferences as they will. A bill, containing a clause exempting labor unions and agricultural combinations from prosecution under the Sherman law, as far as was possible under such legislation, was presented to the President, not against his will, and was signed by him; the Secretary of Labor is proud of his success in unionizing a Maryland coal area that a strike might be declared in sympathy with a strike in Pennsylvania, more than 200 miles away; the United States Printing Office is in the hands of a prominent labor leader. Wholly similar conditions prevail in several of our great states. Congress and legislatures, at the behest of labor unions, enact laws which are prejudicial to the public interests and to the great industrial systems of the land. The whole sympathy of authorities seems to be with the "under dog" of labor. Interference with strikers and their sympathizers rarely begins until destruction of life and property is well advanced. Even then the person of strikers and their sympathizers is strangely sacred; the first volleys of the soldiery must be directed upward, though the volleys from the mob are direct; the person of the guardian of the law is unimportant, but if a rioter be killed, the officer who ordered the volley is in very great danger of criminal process. Protection is given grudgingly to wage-payers, who attempt to conduct their business in opposition to the striking workmen who have abandoned their jobs; introduction of men willing to work seems to be regarded as a crime. The strike of express-wagon drivers in New York city, the recent trolley strike in Indianapolis and that on the Boston Elevated road illustrate the conditions which should bring a blush of shame to the cheek of every patriotic American.

Organized labor, as well said by Governor Brown, of Georgia, is "the most wide-spread and exacting trust in America—levying a toll on all the other elements of our citizenship." Alone of all the great combinations, it can not gain by lowering the price of its wares: it strives to secure a monopoly, that the rest of the community must purchase its wares at an exorbitant price.

These new tribunes of the people, fomenting discontent and class hatred, are sowing seeds which, if permitted to develop, will bring about the destruction of this republic. The time has passed for the comforting reflection that our institutions are secure and that education will prove the cure-all in this "melting-pot of the nations." There is no longer a melting-pot, the elements are incompatible, they can not fuse together. Thoughtful men must unite at once to secure equality of all men before the law, in which alone security for our institutions can be found.

# THE STRUGGLE FOR EQUALITY IN THE UNITED STATES VI

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## The Courts and Property. III

The framers of the constitution were fearful of democracy and entertained serious misgivings concerning the essential goodness of man. In theology, many of them accepted the doctrine of original sin, total depravity, infant damnation and the final perseverance of the saints. In politics, they distrusted the masses, favored a restricted suffrage, provided an electoral college for the choice of president, left the election of United States senators to the legislatures of the several states, contrived the system of checks and balances and established an appointive judiciary with power to set aside an act of Congress. The constitution was the work of the "solid, conservative, commercial and financial interests of the country" who feared legislative tyranny and whose solicitude never lost sight of the safety of property. For a long time, however, the guaranties of property in the constitution were never seriously put to the test. The one noteworthy exception was property in slaves which the constitution failed to protect. Until recently the ownership of property was widely diffused, and because of the abundance of fertile land the man without property to-day stood an excellent chance of becoming an owner to-morrow. There was no wage-earning class destined to remain such to the end of its life. For a time the scarcity of men willing to work for hire handicapped the development of manufactures. It has not been the distinctive features of our form of government so much as our environment that has given us peace with plenty.

It does not follow consequently that our governmental and economic systems, under the conditions which obtain to-day, are proof against socialism. The institution of private property depends upon the general consensus of opinion which varies from age to age. It is a common error to suppose that whatever is always will be. Take the right of a man to interfere with the business of another by normal competition, by way of illustration. This is regarded as a matter of course to-day, but there was a time when the right to engage in a given trade was restricted to the members of a certain guild, and a man was not at liberty to enter any pursuit be might elect. The individual's position in the social order was determined by the status into which he happened to be born and not by competition. Accordingly, the courts in place of upholding the right of competition as at present were once inclined to look upon it with disfavor.[32] Likewise, property rights are no more absolute than is the right of competition. Slave property, once nation-wide, became sectional and then disappeared altogether. Property in general depends as much upon considerations of social utility as property in slaves. For a long time it was restricted to movables. At first it included only weapons and ornaments. Gradually it came to include domestic animals. The ownership of land was vested in the community and not in private hands until comparatively recent times. The powers and franchises granted corporations are wholly optional with the several states, and depend upon considerations of social expediency. But for the social will embodied in positive law, there would be no such thing as theft.

At the present time property rights are being modified in various directions. There is a strong tendency to municipalize or nationalize certain industries. In Ireland, the property rights of the large landowners have been abridged by Parliament. Railway and other labor organizations that occupy a strategic position are altering the distribution of the social income and are establishing a sort of joint proprietorship. This is the effect of "full crew bills." According to the committee of railway managers, the demands of the railway employees on the eastern roads at the present time for an advance of wages are equivalent to putting the income of three hundred and forty millions at five per cent. ahead of the first mortage bonds of the roads.[33] The modification of the liability of employers at common law, the enactment of workingmen's compensation acts and more ample provision for playgrounds, art, music and education by taxation and private benevolence point to the growth of collective property. The social obligations resting upon private property are increasing. The abridgment of property rights is reflected in the lighter punishments provided for offenses against property. Imprisonment for debt has been abolished. The branding of thieves and vagabonds has been discarded. Capital punishment for crimes against property no longer exists. Many punishments which appear cruel and unusual in the light of to-day did not appear so at all to our forefathers. As humanitarian considerations have gained ground, private property has lost something of the sanctity in which it was once held.

It is remarkable how quickly even the staunchest defenders of property sometimes face about and demand an abridgment of property rights. All that is needed is some event that brings out clearly the opposition between private and public interests. A strike that ties up

[32] Bruce Wyman, "Control of the Market," pp. 11–12.

[33] *The Commercial and Financial Chronicle*, July 12, 1913, p. 76.

the steam roads of the country, or the street railway service of a city, may turn out to be such an event. The anthracite coal strike undoubtedly was. No one would probably accuse so "safe and sane" an organ as *The New York Tribune* of socialistic learnings, and yet this paper remarked:

> The old doctrine that a man may do what he will with his own worked well enough when the life of the community was not dependent on what he did own, but some way or other it does not fit the case when a whole community is under one control. It did not seriously matter if one mine was shut down and its product cut off. The community could allow the owner to say it was his, and his use of it did not concern them. But when all the coal mines are subject to one will, the way that will works is of profound interest to those dependent on it. The mines are at law unquestionably private property. Nobody can go into court and get relief because the mines do not produce the coal he needs. But there is a moral trust—even kings now admit that, even though they rule by divine right, they hold a trust for their people. Prerogative and title are with the operators, but the people must have coal, and if the operators forget the moral obligations attached to their property-holding they will force the substitution of legal for moral obligation in some form or other.[34]

If the public mind veers strongly toward socialism, there are at least three ways by which it may attain its goal. First, private property can be more heavily taxed and more heavily subjected to the police power of the state. All of the machinery required for these purposes already exists. No constitutional change is necessary. Private property is held subject to the right of the state to tax. In addition, in such cities as New York, the building department supervises all structural changes or defects in buildings; the tenement-house department regulates the number of windows required for light and air and all alterations in houses occupied by more than three families, and if its orders are not complied with this department has power to vacate property and lock it up; the fire-department prevention bureau has charge of such matters as fire escapes; the board of health sees that certain sanitary requirements are complied with; the highway department requires abutting owners to keep their sidewalks in repair; the state factory inspectors have supervision of establishments where one or more men are employed, and the street-cleaning department looks after such things as garbage receptacles. An increase in the scrutiny of the public eye in each of these directions is easily conceivable. There is no hard and fast line between "taxation, reasonable regulation and fair payment," on the one hand and confiscation, on the other. The difference is a matter of degree and of opinion.

Secondly, a much more important gateway to socialism stands wide open, namely, the regulation of bequest and inheritance, neither of which is a property right under the federal and state constitutions. So

[34] Quoted by *The Outlook,* August 30, 1902, p. 1035.

long as public opinion favors private property, laws governing bequest and inheritance similar to those which exist at present will be continued in force. But if public opinion ever turns in disgust from the existing economic system, convinced of the practicability as well as of the desirability of socialism, a change in the laws governing the descent of property will be one of the easiest methods of approach.

In the third place, the position of the federal courts is not impregnable. Save only the Supreme Court, Congress has power to abolish them. This was actually done in 1801 in the case of the "midnight judges." More recently the existence of the Commerce Court has been threatened. There is no way, moreover, of compelling a recalcitrant Congress to make appropriations for the federal courts, and if so disposed the President by failing to appoint or the Senate to confirm could permit even the Supreme Court to die a peaceful death. Jefferson, Jackson and Lincoln showed that a Supreme Court decision is not binding on a coordinate department of the government. The constitution expressly makes the appellate jurisdiction of the Supreme Court subject to such exceptions and regulations as Congress shall make. On one occasion Congress limited the appellate jurisdiction of the court with a view to preventing it from declaring an act of Congress unconstitutional. This action was upheld by the court itself.[35] It is well known also that Congress can pack the court by increasing its membership. Professor Goodnow aptly remarks "that almost all of the great powers which the federal courts possess are theirs only because of the fact that their exercise of these powers has as a whole been satisfactory to the people of the United States."[36]

## IV

The main reliance of property owners does not lie in constitutions and courts, but in not violating the sense of fair play. The desire for property is well-nigh universal, and, so long as a fair and open field is maintained, the sense of injustice will have little chance to take root, and the army of property owners, both actual and potential, together with their natural allies among those without property, will be too numerous to be dispossessed. The danger to property does not lie so much in the minds of wily agitators, in the ignorance or depravity of the common man, or in the envy which the poor bear toward the rich as in closing the door of opportunity to the struggling and aspiring masses. So long as a man could homestead a piece of land, there was no social problem such as exists to-day. No self-respecting class whose necessities condemn it to a life of barely requited toil can be expected to rest content without at least the hope of something better. There is no

[35] Goodnow, *op. cit.*, p. 345.

[36] *Ibid.*, pp. 343–344.

better way to safeguard property than to give every man a fair start and an even chance in life. No class can so ill afford to disregard the forms of law as the owners of property. To throw labor agitators into jail or to railroad them to the penitentiary on trumped up charges, to seize their persons and deport them from the community by an unlawful exercise of force, or to interfere unwarrantably in any way with their freedom of speech, is undisguised anarchy. Those property owners who make undue exactions, who entrench themselves in positions of privilege, who use the state for their own aggrandizement and for the exploitation of the weak, or who stand out against much needed reforms, are among the worst enemies of their class.

The sooner employers abandon all pretensions to being a superior class appointed by Providence to look after the interests of labor, the better it will be for the property-owning class.

> The rights and interests of the laboring man will be protected and cared for, not by labor agitators, but by the Christian men to whom God in his infinite wisdom has given control of the property of the country.

These are the words of the leading spokesman of the coal operators during the anthracite strike of 1902. They betray a feudalistic frame of mind, and they did more to undermine the right of private property than the numerous acts of violence committed by lawless strikers in the coal fields. It is nothing less than amazing that so astute a business man should have made so glaring a mistake. The divine right of property to rule is no less objectionable than is the divine right of kings. It ill becomes a spokesman of capital to uphold a monopoly in a necessary of life while refusing to treat with a combination of labor, or to lay the responsibility for his own mistakes at the door of Providence. The industrial leadership of the country is in dire need of men of broad intelligence and sympathy, men who are not blinded by class interest and who have a due sense of social responsibility.

Changes in our fundamental law can not be indefinitely postponed by a difficult mode of amendment. In the long run the effect is to irritate the public mind and to accentuate such changes. Until the constitution of Ohio was overhauled in 1912, no amendment could be added unless it received a majority of all the votes cast at an election. Every vote that was not cast for an amendment counted against it. Hence, it was next to impossible to amend the constitution. It is true that several amendments were added during the early part of the last decade. The veto power was given the governor, and the double liability of stockholders in certain domestic corporations was withdrawn. But this was done by the Republican and Democratic parties endorsing the amendments and placing the word "Yes" opposite them on the state tickets. As a result of this strategy, large numbers of uninformed and indifferent voters voted for the amendments. It was only on very rare occasions, however, that the cooperation of the machines of both parties could be secured in this way. The pressure for constitutional tinkering, therefore, increased until sweeping changes were made when the opportunity offered.

On 240 out of the 472 constitutional questions submitted to the voters of the several states in the decade ending with 1908, the vote was less than fifty per cent. of the vote for candidates. In 1910 the vote in Oregon rose to seventy or more per cent. in but 14 out of 32 cases.[37] The heavy handicap of requiring a majority of the total vote cast at an election to adopt an amendment is, therefore, apparent. As a result of this requirement, not a single amendment was added to the constitution of Oregon in the forty-three years ending with 1900.[38] It is possible that both California and Oregon have more recently gone to the other extreme and have made it too easy to amend their constitutions, but a mode of amendment that is practically prohibitory is beyond doubt unsound. Political machinery that compels deliberation and prevents hasty and precipitate action is of the utmost importance to the success of democracy. The formation of public opinion on any question requires time for discussion. The disposition to weigh evidence needs encouragement. Every precaution necessary to both sides of a question having a hearing should be taken. "Tried expedients," "verified conclusions," "traditional beliefs" should not be abandoned without mature deliberation. But when the checks upon the popular will exceed what is necessary to these ends, they not only cease to serve a useful purpose, but become obstructive. Discussion which is stopped at the outset from changing social conditions is useless. When the door to orderly change is closed, the only remaining alternative is revolution.

If the federal constitution were less rigid, both life and property would probably be more secure. A more flexible instrument would not hold things in a vise-like grip, but would permit changes in governmental policy with less social tension. The constitution as it stands leads the courts to make forced interpretations, makes for obstructive delay in the righting of grievances, and pens up the ferment of society until it sometimes threatens the social order. It has discouraged the existence of a party committed to any cause that requires a constitutional amendment. It has helped to make our political contests largely scrambles for offices. So far as principles are concerned, the difference between our leading parties has usually been so slight that it has been very difficult to distinguish between them. In such a humanitarian and democratic age as the present, a constitution that is "based upon the concept that the fundamental private rights of property are anterior to

[37] Ellis Paxson Oberholtzer, *op. cit.*, p. 509.

[38] George H. Haynes, *op. cit.*, p. 24.

government and morally beyond the reach of popular majorities,"[39] and that is at the same time so difficult to amend is out of keeping with the times. So scholarly a man and conservative a thinker as Professor Monroe Smith maintains that

sooner or later . . . it will be generally realized that the first article in any sincerely intended progressive program must be the amendment of the amending clause of the Federal Constitution.[40]

In Kentucky, not more than two amendments can be submitted at a time; in Arkansas, Kansas and Montana, not more than three at a time. In New Jersey and Pennsylvania, no amendment or amendments can be submitted oftener than once in five years; in Tennessee, not oftener than once in six years, and in Vermont, not oftener than once in ten years. A number of states require a majority of those voting at an election for the adoption of an amendment. In these states, a majority of those voting for and against an amendment does not necessarily suffice.[41] No less than forty amendments that have been added to the constitution of Michigan would have failed to carry if this requirement had been in force.[42] In Wyoming, a majority of the qualified electors, whether voting or not is required. In Pennsylvania, an "amendment must be passed by two successive legislatures before it can be voted on by the people, and the legislature meets only on alternate years." [43] The amendment of the constitution of Illinois is especially difficult. A two thirds vote of each house is necessary to propose an amendment. Not more than one article at a time can be amended, and the same article not oftener than once in four years. Finally, a majority of those voting at an election is required to adopt an amendment.[44] As a result, many reforms that depend upon amending the constitution are practically at a standstill. The advocates of different amendments block each other. The friends of the initiative and the referendum prevent the reform of the general property tax and *vice versa.* Each demands the right of way. In the meantime, the reorganization of the judiciary, the short ballot, the abolition of minority representation in the legislature and home rule for cities are obliged to wait.[45] One is reminded of the celebrated Lecompton constitution which was nearly foisted upon the people of Kansas. In providing for its own amendment, it declared: "But no alteration shall be made to affect the right of property in the ownership of slaves." [46]

One might suppose that the constitution of New York is particularly difficult to amend, judging from the amount of criticism which the highest court of the state has excited in recent years. This, however, is not the case. The constitution has been amended on numerous occasions since its adoption in 1894. New York is suffering from the archaic condition of its judicial mind rather than from the rigidity of its constitution. Professor Walter F. Willcox has noted that the court of appeals, in holding the Workman's Compensation Act unconstitu-

[39] Charles A. Beard, "An Economic Interpretation of the Constitution of the United States," p. 324.

[40] *Op. cit.*, p. 673.

[41] Francis Newton Thorpe, "The Federal and State Constitutions of the United States."

[42] John A. Fairlie, *op. cit.*, p. 149.

[43] William Draper Lewis, *op. cit.*, p. 322.

[44] Francis Newton Thorpe, *op. cit.*

[45] See an interesting series of newspaper articles by Arthur M. Evans, in *The Chicago Record-Herald* during November and December, 1913.

[46] "Debates of Lincoln and Douglas," *op. cit.*, p. 109.

tional, substituted its own assumptions for the facts. In the face of statistical evidence to the contrary, the court held that the statute "does nothing to conserve the health, safety or morals of the employees."[47] Such an attitude of mind is unscientific and until it is corrected no mode of amending the constitution, however facile, can prevent salutary measures from being held up for a time by the courts. "A master of legal history tells us that taught law is tough law. Certainly it is true that our legal thinking and legal teaching are to be blamed more than the courts for the want of sympathy with social legislation which has been so much in evidence in the immediate past. One might almost say that instead of recall of judges, recall of law teachers would be a useful institution. At any rate, what we must insist upon is recall of much of the juristic and judicial thinking of the last century."[48]

## Some Pitfalls of Reformers

If property owners now and then stand in their own light, reformers sometimes act with more zeal than sense. The prevailing spirit is too often given to destructive criticism and too little to constructive work. It is too impatient to attain its ends quickly, and relies too little upon the slow-going processes of education. It is too prone to attribute human failure to an unfavorable environment and too little given to laying it at the door of bad heredity. It attaches too much importance to raising wages and too little to stopping leakages, utilizing wastes, and teaching people how to make better use of the resources they already have. It too often imputes improper motives to its opponents. It is occasionally unmindful that there may be honest differences of opinion concerning the wisdom of the remedies which it proposes. It is either too penurious or not sufficiently alive to extravagance in the use of the public money. It has been known to wink at the lawlessness of organized labor while denouncing the lawlessness of capital, or vice versa. It at times needlessly alienates the sympathy of those without whose support it can not succeed. It now and then contents itself with securing the enactment of a statute, forgetful that the laws have no power to enforce themselves. An aroused public opinion is sometimes lulled to sleep by an act of the legislature, and inspectors who do not inspect occasionally give the community a sense of fancied security. Those opposed to a larger measure of social control have been known to withdraw their opposition on the ground that public opinion will not long demand its enforcement. For these and other reasons, the fossilized opponents of reform occasionally render the world a much needed service by calling reformers to account and pointing out their mistakes.

A despotism which secures order, property, and industry, which leaves liberty of religion and of private life unimpaired, and which enables quiet and unobtrusive men to pass through life untroubled and unmolested, will always

[47] *The American Journal of Sociology*, Vol. 18, 1913, pp. 606–612.

[48] Professor Roscoe Pound, *The American Journal of Sociology*, Vol. 18, 1912, p. 339.

appear to many very preferable to a democratic republic which is constantly menacing, disturbing, or plundering them.[49]

These words suggest that the progressive who is true to the interests of mankind is not invariably the foe of property. On the contrary, it occasionally becomes his duty to defend the right of property against its misguided opponents. The abolition of slavery does not justify a crusade against property in general. Human chattels and property in other things do not logically go together. From a social point of view, the two are inconsistent, for the slave has neither the incentive nor the opportunity to become a proprietor. The ownership of one's self is the first prerequisite to the ownership of other things. The total abolition of property rights, or even their drastic curtailment, would promote equality of a certain kind, but it would be equality upon a low level of misery. The lapse of one hundred and twenty-five years has rendered the constitution in some respects unsuited to current needs, but this should not blind us to the fact that the men of substance who brought about its adoption served their day and generation well. They were the real progressives of their time, though some of their work needs revision. Likewise, the opponents of wholesale reductions in railway rates have at times best served the people. Beyond doubt, also, there have been few worse enemies of the ideal of equality than the paper money inflationists who have flourished from time to time. The man who in the midst of turbulence and disorder restores the conditions of orderly industry with a firm hand is the friend not only of property but of labor. But a still better friend of both is he who not only restores order, but who in addition prevents the recurrence of disorder by correcting the conditions out of which it sprang.

The cause of progress commonly enlists the services of the more public-spirited portion of the community. The opponents of the liquor traffic, for example, are undoubtedly less influenced by mercenary considerations than are the liquor interests. It is well to bear in mind, however, that those who take the side of reform at any time are not always such disinterested patriots as one might suppose. Many men engage in politics not for what they can make out of it in questionable ways, but for the love of the game and to gratify the sense of power, and are quite as likely to be found on the side of human rights as on the side of those who have some pecuniary interests to subserve. As any cause gains in prestige, it tends to attract more and more of this class. Moreover, some humanitarian movements are well financed and consequently attract a considerable number of those in whom sordid considerations outweigh everything else. The men and women who espoused the anti-slavery cause at the outset were actuated by high principles, though doubtless some found in the opportunity for notoriety meat for their

[49] Lecky, *op. cit.*, Vol. 1, pp. 259–260.

souls. But when the cause of human freedom became linked with the preservation of the Union and was financed by the government, not only the patriotic and those of high principle enlisted in the public service, but an army of camp followers, cormorants of all kinds and the unscrupulous took advantage of a public calamity to feather their own nests.

"I attribute much of whatever I have accomplished," said a well-known social reformer, "to the fact that I have always been known as a conservative." In like manner, so long as the spirit of progress keeps within the bounds of moderation its future is assured, and neither the opposition of reactionaries nor hostile court decisions can do more than obstruct for a time its way. By the exercise of patience, two amendments have been added to the constitution. If these amendments had failed of adoption, practically the same ends could have been attained in other ways. In the matter of an income tax, the Supreme Court could have been given a chance to reverse itself, or a slightly different law could have been passed which the court might have upheld. More easily still, a substantial part of what was wanted could have been obtained by an excise tax upon corporate and certain other incomes. This device was actually used in passing the Corporation Tax. In regard to the popular election of United States senators, the battle had been largely won in other ways before the constitution was formally amended. If a workingmen's compensation act is held unconstitutional by the highest court of a state, it is possible to amend the state constitution or to pass a law after the fashion of some other state that may pass muster in the courts. If rebuffed by such a decision as in the bake-shop case, it is only necessary to wait and try again when death has recalled enough justices of the Supreme Court to reconstitute its membership. The right, nay more, the duty to criticize the decisions of the courts should, however, never be forgotten. Without criticism it is well-nigh useless to wait with patience. Neither should any one shrink from proposing ideas which may frighten timid souls if reasonably sure of his ground. Many a good suggestion has been rejected only to be accepted later when it is understood. Besides, the saving grain of truth in many an idea that appears crude can only be brought out by discussion, and this can never come about if the idea is kept in a closet and never advanced. The progressive spirit fails of one of its chief missions when it ceases to be educative.

It is sometimes argued that the power of judicial veto ought not to exist in a democratic country. In regard to an absolute veto, the argument is conclusive. Any court decision that for all time stands in the way of what the people want, or that needlessly hampers the popular will, is inconsistent with self-government. But a suspensory veto that can be overcome after due deliberation by amending the constitution is entirely in keeping with democratic institutions. The right of the people to impose such a limited veto upon their representatives and upon the impulses of a temporary majority is as much a part of their prerogatives as anything else. Moreover, the willingness of the people of any country to adopt a written constitution and to invest in the courts the function of seeing that it is not overridden by the caprice of the moment is one of the surest signs of their capacity to govern themselves. The fact that the judicial veto does not exist in England and other important nations does not prove that it can be safely dispensed with here. Any institution that is so closely interwoven with the warp and woof of a political system as is the power of judicial veto can not be safely thrown overboard at a moment's notice. There is probably no charge that can justly be brought against the courts that can not be met by remedies that leave them the power of a suspensory veto, such as enlightened criticism, an elevation in the character of the bench, and setting the courts free from the letter of the law that killeth and from too abject an adherence to judicial precedent. Especially should impracticable methods of amending our organic law be avoided. The case of our highest court is particularly hopeful. In the words of James Bryce:

> The Supreme Court feels the touch of public opinion. Opinion is stronger in America than anywhere else in the world, and the judges are only men. To yield a little may be prudent, for the tree that can not bend to the blast may be broken. There is, moreover, this ground at least for presuming public opinion to be right, that through it the progressive judgment of the world is expressed. Of course, whenever the law is clear, because the words of the constitution are plain or the cases interpreting them decisive on the point raised, the court must look solely to those words and cases, and can not permit any other considerations to affect its mind. But when the terms of the constitution admit of more than one construction, and when previous decisions have left the true construction so far open that the point in question may be deemed new, is a court to be blamed if it prefers the construction which the bulk of the people deem suited to the needs of the time?[50]

The moment progressives offend good sense, they may expect to be deserted by large numbers of their devotees. Take the movement for the free coinage of silver. There is no doubt that the country acted wisely when it rejected "free silver." But it is equally true that the silver propaganda set back the cause of social and industrial reform for nearly ten years. It accentuated and prolonged the hard times following the panic of 1893 until the country was so intent upon the recovery of prosperity that it was almost indifferent to anything else. Many individuals took advantage of the lack of public vigilance to grab franchises, to enact an excessively high protective tariff, and to organize industrial combinations on a scale that ended in startling the financial world, unsettling business, and in reawakening the sense of public duty in the mass of self-seeking individuals.

[50] "The American Commonwealth," edition of 1910, Vol. 1, p. 274.

One of the most common pitfalls into which many men fall is that of pandering to the popular caprice of the moment. He who says the pleasing thing rather than the truth as he sees it is something less than a reformer. The trend of public opinion is entitled to respectful consideration. An overweening confidence in one's own judgment should be avoided. The mind that is proof against criticism or that is indifferent to the opinions of others has ceased to grow. On the other hand, an earnest attempt should be made to set the majority right if it is wrong. Practically every good cause at the outset has been championed by a small minority. The hanging of witches was once a matter of course. The opponents of slavery for a long time hardly dared speak their minds. The opponent of inflation in many states after the Civil War had no political future. It is only a short time since the higher education of women was held in low esteem. He who sets his own popularity above his sense of public duty lacks the moral courage necessary to right the wrongs of the world. The man of fearless and independent judgment occasionally lives long enough to receive the plaudits of his countrymen, but many men who have done the world the greatest service have never had their praises sung until long after they were dead. The fact that a man holds this or that office may indicate nothing more than that he is a calculating time-server.

*(To be continued.)*

# SCIENCE IN NEWSPAPERS

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IT is well known that charlatans and fools sometimes exploit the press for their own purposes. Our journalists are often men of chiefly literary training. They may be able to diagnose a case of megalomania among writers of verse and they may know how to identify a literary pirate. But they are not always prepared to detect scientific frauds or able to discern the fallacies of self-hypnotized persons proclaiming new laws in physics or chemistry. It is no wonder that there exists a general distrust among scientific men for "newspaper science."

This condition is to be regretted. The press is a great educational institution in our age. It is an agent that should be enlisted in the service of science to disseminate knowledge among men. The inefficient service of the American press in this direction in the past is, I believe, a natural result of the momentum of social conditions generally. It is to some extent to be ascribed to the tardiness of our educational institutions in responding to changing social conditions. To be more specific: the journalistic profession is recruited from our high schools and colleges. Few students who have taken up scientific subjects in the curriculum seek, or secure, work on newspapers. Language students, young men and women who have spent their time in studying Greek, Latin, modern languages and literature, are more often given such employment. Suitable courses are not always selected by those who train themselves for newspaper writing. They should be able not only to write good English, but they should also possess a large fund of general knowledge, including the elements of natural science, which now enters into our endeavors almost everywhere.

The above statements express a vague feeling which the present writer has entertained for some time. It has been his desire to investigate the basis for this feeling. When recently an opportunity seemed to offer itself for making some observations on the attitude of the press to science, I decided to make use of it. I collected the reports published by the six dailies of Toronto during the meeting of the Twelfth International Geological Congress, last summer. Copies of nearly all of the six local dailies published from the 7th to the 14th of August were secured, and clippings were made of the reports, articles and items touching on the congress or its members.

The text of these clippings contained about 55,500 words. A rough classification of the contents of this text placed the various paragraphs under nine catagories, as indicated in the following list, where the approximate number of words and percentage of total space alloted to material of each class is also given.

| | Number of Words | Per Cent. of Space |
|---|---|---|
| Reports of proceedings | 14,420 | 26 |
| General information about the congress | 10,510 | 19 |
| Reports of social functions | 10,310 | 19 |
| Personal notes | 6,720 | 12 |
| Interviews | 5,020 | 9 |
| Accounts of geological excursions | 4,020 | 7 |
| Reports on individual papers | 3,160 | 6 |
| Editorials | 1,240 | 2 |
| Discussions of scientific questions of popular interest | 120 | 6 |

About twenty-six per cent. of the space of the text was given to a more or less formal record of the proceedings of the congress, its general sessions, and the sessions of its various sections. A large part of this space was given to the reporting of the addresses of welcome by the government officials and of the replies to these addresses. In the preparation of copy of this kind the reportorial staffs of our large dailies are trained experts and this part of the work was well performed. Not so with the reporting of the professional papers and discussions! Some of the reporters wisely inserted merely the titles of the papers which were read, and the names of the authors.

It is evident that many of these papers were such that reporting even their title seems to have been quite purposeless in a daily paper. The giving of an intelligent statement of their contents by anybody but a specialist would have been impossible. It may have been useless to attempt reporting the papers with such titles as "A physico-chemical contribution to the study of dolomitization"; "On regional granitization"; "Fractional crystallization, the prime factor in the differentiation of rock magmas," and some others. How utterly hopeless it is for the reporter, in journalistic haste, to present to the general reader a comprehensible abstract of a scientific paper, is evident from one report made of a paper on some explorations in South America, by an American geologist. The author is mentioned as attributing the presence of great interior basins to the unequal warping of the earth in the process of elevation. To illustrate this point the reporter then quotes the gentleman as follows:

It might seem strange to you to live 5,000 miles above the sea, but we think of it as a flat plane. First, there is the plateau sloping at the coast toward the ocean, then the pre-Andean depression and again the depression and again the mountains, which are on the average 70 miles across. The streams that flow west through the Andes, causing international disputes between the Argentine and Chili as to boundaries can probably be attributed to glacial erasion.

In another attempt to report the contents of a paper on "The Influence of Depth on the Character of Metalliferous Deposits," the following obscurities occur:

"The deepest borings," said the speaker, "had either copper or gold as their objective, but precipitation was most favorable at a depth of 2,000 to 4,000 feet. A point of great interest was the extent of enrichment in regard to depth, but secondary enrichment was limited to a short stretch below the ground water."

In reporting one or two other papers it appears likely that the writers sought and obtained assistance from some competent source, securing much better results.

Only one of the professional papers was made a "feature," by the Toronto press. This was the paper presented to the congress by one of Toronto's own men, on the subject "An Estimate of Post-glacial and Interglacial time in North America." The "write-ups" of this paper demonstrate that the contents of at least some such papers can be profitably reported even in a daily newspaper, if the necessary effort and space be given to the task. Scientific discussion requires an accuracy of expression that can rarely be attained in speedy writing. To give as much space to other papers as to this one was evidently out of the question, and the editorial management certainly made a proper selection in "featuring" this paper. It treated a local subject of general and popular interest.

Under the head "general information about the congress," were classified such paragraphs as could not be placed in any of the other subjects mentioned in the list. These paragraphs include a variety of subjects, from an account of the history of the organization of the first International Geological Congress at Philadelphia in 1876, and an inventory of all the expenses connected with the present meeting, to the length of time taken for a morning nap by some of the attending geologists on Sunday, and the color of the laundry bill received by another visitor. The matter classified under this head consists of items of information secured by the reporters from any chance source about anything connected with the congress. By inquiry from a foreign member, one reporter appears to have learned the significance of the color scheme of the ribbons worn by many of the delegates on the pins bearing their names, and he wrote a neat little item on "How delegates in the Congress know what tongue to use in greeting." Another reporter, probably less obtrusive, wrote a half column under the heading "Politeness a Feature of Congress," evidently basing his observations on what he saw and heard, without making any inquiries. A paragraph which seems to have been based on some interview was headed "Typical Geologists are not Wealthy." Another article, which was probably written off-hand and as a "bluff," dilates on the guess that geologists know rocks, but are "ignorant of human nature," and that they can neither "bluff" nor "exaggerate." This rather reveals the low ideals of some young men of our day; ideals entertained by a certain class of thoughtless youths in all callings, probably no more frequently among reporters than among others. The best and most effective kind of politics is not the kind that relies on bluffs. While it is likely true that scientists as a class hate sham and exaggeration, it is not to be forgotten that the great recent progress of geology is a direct result of the really effective political talents possessed by some geologists who have held, or who now hold, official positions the world over. Many good geologists are also skillful politicians, not to say that a few have even proved to be better politicians than geologists. As to the discovery that geologists are not a wealthy class, the public was elsewhere treated to interviews with two geologists who were millionaires. Some other millionaires among them seem to have escaped this attention. The space given to the discussion of the private economics of members of the congress must be regarded as a concession, by the knights of the quill, to the vulgar taste of our age, which knows no other measure of a man than his bank account. Everything considered, the presentation to the public of what may be called the general news of the congress was quite complete. Considering that the members of the congress spoke more than twenty languages, while the reporter was limited to two or three, the items of general information gathered were as many and as varied as could be reasonably expected.

One reporter discovered that geologists rarely laugh. "As many as six or eight papers will be read without producing a single flash of wit." To one who attended the sessions and took part in some of the excursions, the fairness of this statement appears questionable, to say the least. While some of the lesser lights of the congress may wisely have avoided any attempt at small wit, there were those who rightly regarded their audiences as consisting of people capable of appreciating humor and who also knew how to indulge without falling flat. In discussing continental movements one of these men said: "It must be a source of great satisfaction to know that the earth in our part is rigid." The reporter evidently took this as a serious statement, for he soon proceeds to make the assertion that "the congress, so far, has not revealed a geological humorist." Evidently the layman is at a disadvantage in this case. He can not always appreciate the background against which the geologists's humor becomes apparent.

In all these three characterizations by the reporters, that the geologists lack humor, wealth and "bluff," there appears a robust survival of an ancient popular attitude to scientists, which is hardly warranted in our time. This attitude is clearly not based on any investigation by the reporters. It is probably the result of high pressure work in filling space. The editorial managers were apparently disposed to give all space needed for ample information to the public on the congress, and the reporters did their best—and worst.

The reports on the congress contain six formal interviews. Two of the interviewed parties were government officials in charge of geological work in two leading nations of the world. The aim of the interviewer is to procure information that shall prove interesting to the public. These two interviews dealt with the organization and the work of the government geologists in the two countries nearest to the meeting place of the congress. In journalistic work local interest is always to be considered. How the popular interest is always uppermost in the reporter's mind appears in the selection of the subjects of the other interviews. One was a Japanese, interesting because of his nationality. Another was an owner of an anthracite mine. The special topic of this congress was the world's supply of coal. The other two interviews aimed to draw interest by the subjects touched upon—the geology of biblical lands, and the age of the earth expressed in years. The latter subject is twice discussed in the interviews.

From the point of view of the public it is perhaps to be regretted that scientists are averse to being interviewed. They hate to be quoted incorrectly, and they have a great dread for professional criticism. They fear to be suspected of too much appreciating popular recognition. This looks like moral cowardice. Really it comes from the fact that men of science in their work must necessarily ignore popular beliefs and popular recognition of the truths they may discover. But this is no reason why they should be disinclined to make some sacrifice for the education of the public.

All social functions of the congress were reported with fulness and detail. There were the usual descriptions of the gems and laces worn by the leading ladies and there were the customary accounts of felicitous remarks uttered by the men who spoke the toasts. The arrangements made for the entertainment of the visitors on each of these occasions were also adequately described. Here again the demands of local interests were met by the papers. They were performing an every-day duty to their home constituents.

About twelve per cent. of the text may be classified as personal notes on individual members of the congress, light biographical material. Such attentions were naturally given to men in high official positions, men of great renown, or people of unusual and striking accomplishments. The task of selecting the right material was, no doubt, difficult. One prominent foreign delegate was "featured" in this way, because he interests himself in politics and is a leader among the socialists in his home country. In some cases the selection must have depended on the chance of finding the information supplied. No doubt much more "copy" of this kind might have been secured. Everything considered, this class of copy must have been interesting reading for the public. No one can question its educational value. To the members of the congress themselves it was a help in learning to know each other. In two exceptional cases these sketches may have been unnecessarily embarrassing to the persons concerned, owing to the well-known journalistic tendency to be sensational. The contents of the headlines must have appeared brutal to a Chinese geologist, whom they proclaimed as having arrived in Toronto "in bond."

The many excursions arranged under the auspices of the congress received ample attention, seven per cent. of the text reporting such events. Preference was given to details of general human interest, such as the mode of travel, the personnel of the excursions, and some untoward or amusing incidents. Some reporters appeared disposed to furnish entertainment to the reader at the expense of the excursionists, as when they related in mock-heroic style the vicissitudes of an "armada" of steam launches exposed to a rough sea on an excursion to Scarboro Heights. Though it appears that the press reports might very profitably have presented more of the scientific significance of the things seen on these excursions, any such purpose on the part of the reporter promptly gave way to the dominant instinct of his class to entertain rather than instruct. A visit to the Don Valley, altogether without exciting incidents of any kind, resulted in more serious, though quite brief, references in the papers to the significance of the phenomena noted on the trip.

Editorial writers are usually not interested in the world of science. Nevertheless, some editorial comments on the congress were made in the Toronto papers. These touched on the practical utility of scientific research, and on the relation of society to physical sciences in general. They expressed also a mild defence of these sciences, stating that they are in the popular mind unjustly associated with gross materialism.

The fertile resources of the reporters were shown in their interviewing at least two geologists on a subject of unfailing popular interest—the age of the earth. One of the interviewed gentlemen was quoted as making his estimate 200,000,000 years. Another geologist said it was an unprofitable subject to discuss, and that different people meant different things in speaking of "creation," or of the beginning of the earth. The truth of this latter statement became quite evident in the discussion at one of the sessions of the congress, but this perhaps escaped the attention of the reporters.

The total space given to the reporting of the congress was nearly 3,000 square inches. Of this space about sixty-seven per cent. was text, seventeen per cent. was given to the reproduction of photographs or to other illustrations, and sixteen per cent. was taken up by large headlines. There were reproduced the likenesses of fifty-one individuals connected with the congress. Two parties were thus presented to the public four times; seven, twice; and the rest of the fifty-one, once.

In the selection of subjects for illustrations it appears that popular interest was also considered. Gems have an attraction for many, and so have foreigners. The public enjoys what is picturesque. We all like to know the faces of men in high and responsible positions. All this the editors take into consideration.

Some conclusions drawn from this reconnaissance of what the journals of Toronto produced on the meeting of the Twelfth International Geological Congress, may perhaps be mapped in rough outline as below: There is certainly no desire on the part of the press to misrepresent or suppress science or its devotees. The urgent haste imposed on the work of our journalists naturally prevents them from competing in accuracy either with scientists in general or with geologists in particular, whose productions it may take a lifetime to prepare and several years to publish. The same haste sometimes forces editors to use copy which should be consigned to the waste-basket.

The contents of our newspapers always reflect the tastes and the interests of the general public. In the schools attended by those who constitute the reading public to-day, science teaching was defective. Hence, perhaps, the weak public demand for reading on scientific subjects. The looseness of the elective system in our secondary schools is perhaps responsible for the fact that many reporters are sadly ignorant in even the rudiments of science and altogether incapable of appreciating or describing in the most general way the proceedings of such a body of men as met in America on this occasion.

The undesirable result of this shortcoming of the press in its important function as an educator might easily be remedied by cooperation between scientists and journalists on occasions like this meeting. The press should make sure always to be just a trifle ahead, in knowledge as well as in "smartness," of the public it educates.

The elevated position of the savant, intellectually, does not relieve him entirely of general human duties to his fellow men. In the organization of the mechanism of a general congress of scientists of any group, a press committee would be neither a superfluous nor a disgraceful feature. We are all human. A meeting of this kind should be made to hasten the time when the public will demand reliable reports, not only on sports, trade and politics, but also on science.

# THE SCIENCE OF HISTORY

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NAPOLEON'S cynical question, "What is history but a fiction agreed upon," suggests a criticism that nervous historians have always felt the need of answering; and much investigation and many speculations have been directed at the adverse critics in the hope of placing the popular science in that favored class where are found such unassailable sciences as chemistry and physics. The discussion of the proposition, "Is history a science?" depends so completely on the definition of the term "science" that one is tempted to take refuge with Mr. Freeman behind the old English equivalent, "knowledge." The failure to recognize the difference between the phenomena of history and those which interest the natural scientists and the disinclination to accept limitations not common to all sciences have always been the stumbling blocks for those theorists who would lead history along the path of objective certainty. History has its limitations and to ignore them is not the way to create a science; but rather we must state exactly what can and can not be known, so that we may escape the will-o'-the-wisp kind of sport, a pastime much favored by the speculative historian. It is, therefore, necessary to recognize the peculiarities of the phenomena, of the problem presented by them, and of the method which can be employed.

For the purposes of this paper the phenomena of history, the activities of feeling, thinking, willing men associated in some kind of a community for mutual protection and benefit, need not be dwelt upon, nor is a discussion of the well-known complexity of such phenomena demanded. Their most conspicuous characteristic is that they all belong to the past. Whereas in other sciences the facts are open immediately to experiment or observation, the events of history are studied mediately through the reports of them, except in so far as actual remains have sporadically reached us. With a liberal interpretation, Mr. Froude is right in saying:

> Historical facts are of two kinds, the veritable outward fact—whatever it was which took place in the order of things—and the account of it, which has been brought down to us by more or less competent persons. The first we must set aside altogether. The eternal register of human action is not open to inspection.

Yet the lack of faith in his witnesses, which is the conspicuous characteristic of the modern historian, is the safeguard against deception. We have passed far beyond the naïve credulity of the medieval annalist and demand of every historical source proof of the truth within it. We must know which of our sources we can trust and how far we can admit them as witnesses of the fact and what was the fact.

Every period of the past offers difficulties and obscurities peculiar to itself. The sources are either too meager for the precise determination of the event, or as in the modern epoch, so multitudinous that the historian is bewildered by the reports of special commissions and the published and unpublished documents, so that he can only hew a pathway through the wilderness. Further the very personality of the writers makes his task more difficult. If they are ignorant, can he trust them? Are they prejudiced, will he not be deceived? Are they learned, can he give due allowance to the ideas and ideals, social, political and religious, with which they weight their narrative? Thus at the very beginning of the science, in seeking to get at the phenomena, there is endless research to obtain information more or less questionable. For this purpose there has been elaborated a method which is scientific both in spirit and in the results obtained. Yet at this point, however cautious the examination of the sources, there enters an element of doubt into our knowledge of what occurred in the past. On such foundations historians should not seek to build too imposing an edifice. A careful study of the means of construction should be made in order to raise a superstructure whose form and weight have been carefully adjusted to the weakness of the substructure.

The historical problem must, therefore, be stated with a full consciousness of the peculiarities of the phenomena. Now a scientist may attempt to analyze his phenomena and disclose their constituents; he may seek to discover the essential laws of their being; or he may simply trace their growth. This last is unquestionably the point of view of historians. As Dr. Bernheim says:

> History is the science of the evolution of man in his activities as a social being.

The idea of evolution is peculiarly an historical one; that events are not isolated, but fit together as cause and effect of an ever-changing whole, is the assumption which underlies all historical knowledge, without which no progress can be made; every movement of the world's history conditions the next, although the finite mind is unable to follow the line of connection at all times. The fact that history traces an evolution separates its problem definitely from that of sociology, with which there is such danger of confusion, for the phenomena of the two sciences are almost the same. Sociology is the science of social statics, history of the social dynamics; the one studies the average of masses, the other individual facts or events; sociology would explain the mechanics of society, history the development; the former seeks to discover the general laws underlying the particular phenomena, while the latter is contented to trace the life history of the particular event. It is that in which history is interested, the individual fact with all the differences, marking it as something unique in the past. Sociology studies the same phenomena, but draws from present and past in her search for conditions of like kind, disregarding individual variations, and therefore hopes—so far without much success—to find types and even discover laws. What sociology with its different point of view and method may hope to acomplish is not a part of the historical problem.

The demand has been made of the science, however, that it disclose the laws of social dynamics. The futility of such an attempt will be more fully seen after the discussion of the method of reasoning in history; but at the present moment it is sufficient to note that to discover a law by observation—the only method capable of being employed by the historian—there is need of finding a type or typical development, the law of which will be the law of all similar phenomena. It is not to be denied that there have been in the past certain recurrences of similar forms which some philosophers have eagerly asserted to be typical regularities of social development from which laws may be learned. On account of the complexity of the phenomena, in which these similar elements are closely interwoven with variants, and because the observations at best are unreliable and can never be corrected by repeated trial, a complete knowledge of the conditions or of the occurrence is not possessed by the historian and there is, therefore. no secure basis for an induction. Besides the collection of a number of similar facts from various periods is not the usual method of the historian in whose eyes events are individual in character, never combining the same conditions, never following the same course. These very differences are those which he seeks. Even here he must acknowledge himself baffled in his search for the sufficient cause of these variations which mark them unique. He finds their beginnings and traces their development, but, as far as his knowledge goes, it is conceivable that quite another succession of events might have been enacted, and then he would have zealously shown how it too fitted into the evolution past and present and interdigitated so accurately with the other phenomena. From the observation of an isolated event, dissimilar to all others, no law can be formulated.

From another point of view attempts have been made to discover the laws controlling historical development. The world's history is continuous; each nation, each period forms but a part of the grand whole; on this broader field can we find laws of historical evolution. We historians stand in a very different relation to our phenomena than does the natural scientist; in the twisting and squirmings of the microcosm we read our own destiny. Never can we get outside of the course of the evolution of which we are ourselves a part, and view it as something entirely foreign to our wills. An objective criterion of the truth, although not wholly lacking, is still by no means so perfect as that offered the natural scientists. But a still greater difficulty confronts us; there is no whole and completed development in the world's history; the beginning and the end are unknown; the origin is shrouded in darkness; before the future there hangs the veil of Mayo; we can observe the pupa or cocoon, but not the caterpillar and moth. Under such conditions every explanation must be subjective in character.

Leaving then to one side the search for laws of social dynamics, the historian contents himself with disclosing the causal relations of the successive movements in the evolution of human society, and this is the sole aim of history; but even here the science is subject to important limitations for the use of experiment is impossible, so that the method must be that of observation. At best many disadvantages confront the observer, which are not encountered by the experimenter, so that his results form a very insecure basis for induction, unless, as in other sciences, his observations can be often repeated and the human senses aided by sensitive instruments. But repetition and the use of instruments are not for the historian, who works over the observations of the untrained minds of the past. In seeking the cause or causes of any phenomenon the natural scientist views it as a type of a large class; and even in the case where causation is determined by a single experiment, there always exist numerous phenomena of the same kind or else the particular phenomenon offers itself to the possible repetition of the observation, so that the assurance of the opportunity of repeating the test case plays an important part in the induction. The scientist abstracts from the occurrence all individual variations and finds the cause of the typical phenomenon, which is generalized in thought so as to cover all individuals of like kind. Thus are obtained causal relations, which have objective truth. Such a method of abstraction is inapplicable in history, for, as we have already seen, from the point of view of the historian each phenomenon is exceptional and can not be classified to find types, and also the same conditions and events never recur.

In the search for causal relations how far is it possible to make use of the canons of inductive logic? On account of the reasons stated above it is impossible to find two events which agree or disagree in all respects except one. Therefore the canons of agreement and difference are of no assistance in historical research. The impracticability of these canons in history has always been acknowledged, and yet the literature of history as well as of sociology and economics is filled with errors arising from their unscientific use.

Of the inductive canons there remain those of residue and of concomitant variations, neither of which is a very safe criterion of causal relations and both of which can to a limited extent be employed by the historian. When there are general propositions proved by other sciences, such as psychology, sociology and economics, which will establish the needed partial causation, the canon of residue can be used. The value of such reasoning will depend on the reliability of the general propositions and on the historical possibility of their being true when applied to the conditions of a society of the past. Again the certainty of the result will depend on the assurance that the historian has discovered all the conditions, and this will always remain an open question. The reverse process, so popular with sociologists and psychologists, is also of some service. By the collection of the data of individual acts and striking an average, the personal volitional element can be approximately eliminated, and the residue over and above the probable conduct reveals a partial cause of the activities of the masses. Besides the meager data which the past affords and the impossibility of sending elaborate questionnaires to past generations, both of which facts hinder the use of this method, the results reached by such means show only the general tendency, the probable action, and not the particular acts and motives which form such a prominent feature of history.

The true method of history would seem to be the canon of concomitant variations; but unfortunately there is no invariable measure, as in the physical sciences, by which variations can be mathematically determined. All elements of social life vary continually. If we select one as a measure for all, we may be using that which is most variable and certainly one of the causes of variations in other elements of society. In fact a social yard-stick is wanting. In the study of primitive society this canon has been employed successfully because of the large number of similar phenomena, both past and present, but it fails to satisfy the needs of the historian of a civilized people.

By this hasty review of the canons of inductive reasoning, it is seen that only two, and these the least desirable, can be employed by the historian, and then with very material limitations. History is not a science of pure induction and never can be. The facts of history could never be joined into causal relations by induction alone. If there were no other means, history would remain chronology.

How then can causal relations be established by the historian? The answer is: "By deductive and teleological reasoning, for the most part by the latter."

The past illustrates the operation of the laws which have been established by the social sciences. The method of deduction can be employed in cases where individual volition can be eliminated, where causes psychological or economic affect large masses of individuals, bringing about important historical changes. In tracing economic development and social psychic life this method establishes causes which satisfy the mind and a large mass of historical knowledge is thus removed from the charge of uncertainty.

As a rule, however, the historian's view of the past is teleological. We are obliged to pass from effect to cause just as we do when reviewing our own lives. Knowing the end reached by human society at any period, we trace back the events which have been the means of bringing about this existing state. Every event is a means to an end; it is purposive. Either some seemingly unimportant event has widened into numerous ends or the many events have united to produce a given end. According to this point of view, the historian eliminates factors which seemingly have no purposive relation to the result. These effects are employed to explain causes rather than that causes are shown blindly to produce effects. As Mr. Freeman constantly insisted:

> You can not understand the present without a knowledge of the past, nor can you understand the past without a knowledge of the present.

The present is the purposed end and is to be explained by the means which brought it into being. The past is the means and can only be understood in the light of the end which it is to bring about. In the natural sciences there is no such view of phenomena as this predominating. Chemical affinities are not regarded as means to bring about ends, but as forces which produce effects blindly and necessarily and will do so on all occasions; there is nothing arbitrary about the individual result; but in history we are dealing with human society, where movement is caused by volition, by "individual will acts." As far as man can perceive, history is made, not entirely, of course, but very materially by purposive ideas and not wholly by the blind action of chemical-physical forces.

Instinctively one asks whether this teleological view corresponds with the actual state of society, and the answer must be negative. Studying society carefully before any great historical movement, it would seem that out of it any number of events might emerge. There are possibilities of many great movements from the conditions present; and, after we know the outcome, we have a case of double sixes appearing when the dice are thrown. We may argue from the double sixes back to the cause, if we will; but from the causes ascertained by us, double twos might have resulted as well. The solution of a problem in probabilities is the final result of any science which studies human dynamics.

We have hit upon the weakness in any argument to prove history a science comparable to the natural sciences. The scientist believes in the universal reign of causality and fixes as the goal of his search the establishment of causal relations between his phenomena which have truth in reality, that is, objective truth. The belief in the persistency of such causal relations assures him that there lurks no subjective element in his result. Now the phenomena of developing society are of such a nature that any association of causal relation between them will generally contain an element of uncertainty, because there is lacking an objective criterion; and hence the mind hesitates to assume that a knowledge of the complete cause is ascertained or that the effect must have followed the causes which can be determined. That all which happens in society is the result of effective causes can not be denied by one believing in the uniformity of nature, but it is denied that the mind is able to peer through the darkness of the past and see the hidden workings of forces in the soul of humanity.

Historians have been loath to acknowledge frankly this limitation, and instead have promulgated various theories to account for human phenomena without even a tacit assumption of ignorance. They would prove that history has been caused by universal forces, cognizable by man, and that man is an automaton, tossed hither and thither as the forces of the cosmos have acted upon him. To this end social evolution has often been likened to the life of a living organism and the resemblances are sufficiently remarkable. It is influenced by its environment; it has its separate parts with their functions; blood vessels and nerves are not lacking; and the cells are the individuals of which society is composed. The simile is a very happy one, but it remains a simile.

Misled by the resemblances, historians have often sought to carry over into their field of inquiry the methods of the biologists, hoping thus to silence forever the denunciations of inexactness and to establish causation in their science in the same way as it is done by the investigations of the life of the lower animals and plants. According to this theory, the cosmic causes of the varying phenomena among people are to be sought in their physical environment. In the ultimate analysis, natural variations must be derived from the same source, for "we can not regard any nation as an active agent in differentiating itself. Only the surrounding circumstances can have any effect in such a direction." Yet as far as the historian is concerned these national varieties are the most important facts in his knowledge and the ultimate explanation of many events in the world's history. As Mr. Symonds says,

> Nothing is known for certain about the emergence from primitive barbarism of the great races, or about the determination of national characteristics. Analogues may be adduced from the material world; but the mysteries of organized vitality remain impenetrable. What made the Jew a Jew, the Greek a Greek, is as unexplained as what daily causes the germs of an oak and of an ash to produce different trees.

History has to accept this dissimilarity of peoples with all its results, for an unproved hypothesis should not form the foundation of its method.

Closely connected with the above is the still unsolved problem of heredity. Is not heredity one of the great causes of variation among men and hence an important factor in the production of historical movement? This question, to which I shall return later, must be answered in the affirmative by the historian, to whom the differences between individuals and between nations are conspicuous characteristics of his phenomena, and as far as his information reaches are due to the accidents of birth as well as to environment.

Furthermore, the biological historian slights the great internal fact which separates the social organism from all others and makes it a unicum, to the study of which the biological laws are not applicable, namely, the social psychic life which is such a large factor in the evolution of man. It is a characteristic of highly organized society to wean itself from that dependence on the physical environment which is such an important element in the lives of animals and savages. Therefore a community of human beings can not be treated as an unconscious organism, wholly conditioned by its material surroundings which create blind forces determining its development. Organic needs do not make psychic factors subservient to them, rather the opposite is the case. Mind exercises a control over the material needs and directs the exertions of society. The vague use of the terms of biological science, natural and sexual selection, when employed in speaking of the social evolution, seem more metaphorical than real; for on this higher plane of life the two laws play but a very subordinate part, both being subservient to intelligent choice without the necessary result of the elimination of the weak and "unfitted." The mental life of man, which takes the forms of religion, science, art, and mechanical inventions, creates an environment of a wholly unbiological character and becomes by accumulation a tradition, a psychic environment, or rather it is the soul of the organism; for the individual men, the cells of the organism, change but little from generation to generation and do not alter their physiological character, nor do they, as ages pass, acquire any great increase of power, mental or spiritual. The evolution, in fact, during the historical period is transferred from the individuals of society to the social psychic environment of the community, which undergoes changes from age to age, as the activities of men of successive generations add their portion to history. Thus no physical and physiological analysis of this peculiar organism can satisfy the requirements of our science. After the study of the economic struggles and the institutions of any period, which also have a psychic side, there remains for the historian the tracing of the mental and spiritual life in its various and complicated forms.

Certain theorists claim that we have in this psychic environment a means of determining the sufficient causes of historical events. The physical and psychical environment together reveal the sufficient reason for the acts of any generation. There can be no question of arbitrary self-determination: for, born into certain conditions, man acts as the forces physical and spiritual compel him. Given the territory, the national characteristics, the institutions, the social psychic environment and we have history a connected whole with cause and effect verified as in the natural sciences. The activities of individuals in relation to these great forces are like the waves on the surface of the deep ocean. A man may raise himself above the level a moment but sinks back, having affected the whole so little that the historian can eliminate the free-will acts of individuals and treat only the life history of generic man. "The new direction of historical investigation," says Professor Lamprecht, the leader of this movement, "has first brought pure causality into history, because it seeks to prove the causal coherence of the generic life of man, and does not confine itself to the deeds of eminent men." It is not to be denied that such an historical hypothesis has value, but it is one-sided and, as far as our knowledge goes, is but half a truth.

It has been already shown that from the nature of the subject matter, history is concerned with the particular rather than the general. It is the personal act amidst the almost never changing activities of the masses that interests us. This personal act, however, is an unknown quantity in every generation. The generic man is but an average of the community, within which there are numerous variations, just as is found by the naturalist among the individuals of any species of animals. These variations are not due wholly to the physical and psychical environment, but come partly from the accidents of birth, which the historian can not trace to their first cause. The forces which are to produce historical movements are not existent except in the souls of these individuals of which the average of any given community would take no account. The social psychic environment will affect and develop these variants in different ways, and the sum total of these variations will give rise to historical phenomena which would not be perceived in the external causes acting on the community.

After the fact we can know the effect, but why there was that particular effect instead of many possible others escapes our search. Within the zone where past tradition meets present variations, we can not follow the intricate working of forces. In the last analysis, therefore, an important cause of historical phenomena lies in the soul of the individual and must be sought in his variations from the multitude, a mystery locked in the secret chambers of the germ cell, in his relation to the past, which constantly changes with the person, in his motives of action, which can not be massed with those of his fellows. Infinite knowledge may follow amidst the complex mingling of will and will, desire and desire, of the millions of individuals the line of cause and effect, but man with human intelligence stands in the presence of any generation as before the entrance of a dark cavern into whose innermost recesses his eyes can not penetrate.

The higher the civilization the greater these variations from the average. Savages are much more similar psychically than the more civilized, just as plants conform to the type closer in the natural state than in the cultivated. It is this close approximation to a type that gives the biologist encouragement in his investigation of the life of the lower organisms. As soon as he is compelled to acknowledge the entrance into his problem of individual volition, his hope of discovering laws or causal relations similar to those found by the chemist or physicist is limited just as is the case of the historian. In civilized nations the variations among men are multitudinous. Amidst such great dissimilarities can we talk of a generic man? Is every one compounded of two parts, a personal and generic?

There are times when the contrary theory seems justifiable, when one is willing to declare with Emerson:

> Every true man is a cause, a country, an age: requires infinite space and number and time fully to accomplish his thought—and posterity seems to follow his steps as a procession. A man Cæsar is born and for ages after we have a Roman Empire. Christ is born and millions of minds so grow and cleave to his genius, that he is confounded with the possible of man. An institution is the lengthened shadow of one man, as the Reformation of Luther—Methodism of Wesley. All history resolves itself very easily into the biography of a few stout and earnest persons.

To outward seeming eminent men are the result of fortuitous variation and are similar to the "sports" of the biologist, since the connection between them and their origin remains even more obscure than slighter variations; and these "sports" of history are unquestionably the direct cause of changes in the community. Their peculiarities are preserved, permeate the whole mass of individuals and become in time part of the social tradition. The simile of the deep ocean of social psychic life and the waves of individual activities does not present the correct picture, for the waves subside and leave the depth of the ocean the same, while the influence of the individual does not disappear but lives on after his death, increasing the extent and variety of that environment out of which he came.

The limitations of the science of history are very real. The phenomena are hidden in the past from personal observation, are the most complex of all sciences, are unique in character and apparently the result of the will acts of individual men, whose motives are derived from mingled hereditary and environmental influences. At times the historian can by induction or deduction discover a sufficient cause of the phenomena, but more frequently he is obliged to acknowledge the impossibility of unravelling the tangled thread of causal relations amidst the purposive and arbitrary acts of millions of individuals. As historians must seek for the social forces in the souls of the individuals composing society, historical cause will always remain in the circle of probability and thus differ from the causes established by scientists in the physical and biological world.

# THE PRACTICAL NECESSITY OF SCHOOL CLINICS

By E. H. LEWINSKI-CORWIN, Ph.D.

EFFICIENCY was defined by one of our great American engineers as "the relation between *what is* and *what ought to be.*" Judging by this standard and agreeing on the premise that one hundred per cent. efficiency in medical school inspection means a complete discovery of all of the ailments and defects of the children followed by a prompt, rigorous and effective alleviation and cure of them, so far as they can be alleviated or cured, we must admit, in the light of established facts, that we have not only failed to reach the uppermost notch of efficiency, but that we are quite a good distance away from it. I shall not attempt to reproduce here the tables of statistics showing the number of defects noted in the schools of this and other countries and the corresponding statistics of treatments and results of treatments. They are in a general way known to all of us. In New York City in 1911, for instance, 166,368 children were found to be needing treatment, of whom 65,150—or not fully 40 per cent.—were reported as treated. We don't know how many of the defects noted were actually remedied, as there is, of course, a difference between reported treatment and actual cure. A single visit to a dispensary is considered as treatment, and there is no law whereby the Health Department of the city can enforce further action, even if in its opinion the treatment is inadequate. Nor is such a law desirable. We are evidently not accomplishing fully what we have set out to do. There is a serious gap between our aim and its fulfilment.

Efficiency depends almost wholly on the application of certain broad general principles. When our work proves to be falling short of efficiency we must either change our methods of procedure or revise the underlying principles governing them, or both. One of the principles of medical inspection of school children is to point out defects, leaving it to those most interested in the welfare of the children to have them attended to and treated—a perfectly reasonable expectation which, however, like many other social theories and assumptions, is, unfortunately, not being borne out by actual facts.

Many parents are ignorant, many negligent and indifferent, many are overworked and indigent. Campaigns of education and social reform will undoubtedly decrease the numbers of the ignorant and the indigent, but this is a slow process. If our faith in school medical inspection is justifiable and if we really mean to decrease the appallingly large amount of illness and physical discomforts among school children and conserve their health, thus promoting well-being and sound education, we must recognize that our underlying principles must be altered and actual conditions met more satisfactorily than by mere observation and noticing of defects.

Medical inspection of school children is in its infancy. Before a satisfactory method will be worked out many experiments must be tried out and many careful inquiries made. The present fragmentary study was undertaken on behalf of the public health, hospital and budget committee of the New York Academy of Medicine to demonstrate a method of testing the value of certain elements entering into the effectiveness of our medical school work, in order to determine whether school clinics are a practical necessity. Matters pertaining to the health of the school children of the City of New York are confided to the care of a dual authority—that of the Department of Education and the Department of Health. The sanitary care of schools, the instruction in physical training and personal hygiene, the segregation of backward and mentally defective children, are entrusted to the Department of Education; all the other elements of the medical school inspection are under the control of the Department of Health.

There are instances where the work of the two departments overlaps; there are instances where the two departments collide. There are opportunities for mutual dissatisfaction and irritation, which at times engender ill-feeling and refusal to cooperate on the part of individuals. We shall eventually come to the point, it seems to me, when we shall have to decide on some definite policy of procedure, which will eliminate any possibility of friction. We should like, therefore, to know precisely to what extent the full and complete cooperation of the teaching staff with the medical corps is to be counted on as a factor in bringing the efficiency of our school medical work to the highest possible pitch. Then, we have a great many dispensaries in the City of New York, varying in size and efficiency. The knowledge of the extent to which the proximity of a large and well-equipped dispensary affects our problem is also essential before a definite policy is adopted. Thirdly, we harbor within our city limits population composed of various races, of various degrees of intelligence and education and differing in economic status. We should like to know to what extent these factors enter into our problem.

Recognizing the importance of these elements, we have selected four schools in the Borough of Manhattan: One on the lower east side, in a section whose population is composed almost entirely of Russian, Austrian and other Jews, and where the cooperation of the school authorities with the health officers is known to be excellent. Then, another school amidst a mixed population—foreign to a great extent, where the interest of the principal in the work of the health department's officials was known to be slight. A third school was selected, again in a Jewish quarter, but in another section of the city, near a large and efficient dispensary, and a fourth school in a representative well-to-do district of the city. It was impossible for us to go over the cards for all the children of those four schools, so we decided to take as many cards as we could get for one class of each grade of the schools in question, endeavoring in this way to bring into the study children of all ages in each school. In all we have examined 1,452 records. From these closed records for the first term of 1912–1913[1] we have tabulated the number of children suffering from physical defects, but have not included cases of contagious diseases or communicable diseases of the eye and skin, as they are being treated in schools, so that our inquiry referred only to cases of defective vision, defective hearing; defective teeth, primary and permanent; defective nasal breathing; enlarged tonsils; defective nutrition; cardiac, nervous and pulmonary diseases; and orthopedic defects.

There were 1,617 cases of these defects alone noted for the 1,452 children whose records were examined. Bad teeth constituted two thirds of the defects. While the per cent. of all the defective children found among those investigated in the four schools, exclusive of bad teeth, was 41, it varied from school to school. It was 40 per cent. on the lower east side, 54 per cent. on the east side in the neighborhood of 30th Street; 21 per cent. in the well-to-do uptown district, and 50 per cent. on the upper east side near 103d Street. Of all the defects, bad teeth were most poorly attended to. In the school in the foreign district of the city where cooperation of the school with the medical corps was very good, 90 per cent. of the cases of defective permanent teeth were treated, but none of the 147 children with carious milk teeth received any treatment. In the school where cooperation was poor, 28 per cent. of cases with defective permanent teeth were treated and no primary teeth defects were reported remedied. In the school in the well-to-do section of the city, 56 per cent. of cases of bad permanent teeth were treated and 17 per cent. of bad primary teeth. For the school near the dispensary, 35 per cent. of bad permanent teeth is reported as treated, and out of the 239 cases of primary bad teeth only 1 is reported as having been treated. As to other defects the cooperating school reported 94 per cent. of children with defects receiving treatment as against 65 per cent. for the school whose attitude was antagonistic to the Department of Health. The well-to-do section school reported 80 per cent. of its defective children under treatment, and the school near the dispensary reported 86 per cent. under treatment. If the teeth defects be counted in, then the per cent. of treatments for all the defects, other than communicable eye and skin diseases, will respectively be: 47 per cent., 32 per cent., 54 per cent. and 41 per cent. As to individual defects, the following table shows the per cent. of treatment in the case of four chief classes of defects:

[1] In the case of School No. 171, the cards for the year 1911–12 were used, because the records for the first term of 1912–13 were unsatisfactory

TABLE I

| | Defective Vision, Per Cent. | Defective Nasal Breathing, Per Cent. | Enlarged Tonsils, Per Cent. | Teeth. | |
|---|---|---|---|---|---|
| | | | | Primary, Per Cent. | Permanent, Per Cent. |
| *School A:* lower East Side, good co-operation................ ...... | 75 | 100 | 95 | — | 90 |
| *School B:* neighborhood of 30th Street and 2d Avenue—bad co-operation........................ | 55 | 63 | 70 | — | 28 |
| *School C:* uptown well-to-do district................................ | 90 | 91 | 80 | 17 | 56 |
| *School D:* upper East Side near a dispensary... .................. | 85 | 95 | 82 | .4 | 35 |

The numbers of other defects are too small to be of use for comparative purposes. The table shows that eye troubles receive treatment in 55 to 90 per cent. of cases and that adenoids and tonsils are attended to in from 63 to 100 per cent. of cases. Evidently special stress, at times too much stress, is being laid on this class of defects. It is instructive to note that at times with full cooperation of the school authorities it is possible to attain 100 per cent. of treatments in certain classes of ailments. Teeth present the poorest showing as to amount of attention and treatment given, even in the well-to-do section of the city.

As has been already mentioned, reported treatment and actual results should be regarded as two distinct statistical categories. Under existing conditions, figures of treatments should be taken with great reservation as an indication of efficiency of results attained by medical inspection of school children. The school health records indicate the number of cases which in the opinion of the school doctor were cured or which improved under the reported treatment. Tabulating these statistics, I find as far as the cases are reported that, exclusive of teeth, out of 482 cases treated only 204, or 42.3 per cent., have been cured, and 96 cases, or 20 per cent. have improved. The remaining 37 per cent. are not recorded as cured or improved. Granting that among the defective children under treatment there were a number of incurable cases, and allowing for clerical errors of omission, 38 or 30 or even 25 per cent. of non-cures and non-improvements in school children is a very high percentage. Aside from mere figures, experience shows that a large percentage of those reported treated do not improve, a condition which calls for serious consideration and which is due in a large measure to slipshod therapeutics in dispensaries as well as by some private physicians, especially in the poorer sections of the city.

Contrary to the prevailing notion of the abuse of dispensaries by patients able to afford a physician's fee, the statistics for the four schools as to source of treatment, show that 235 of the 482 cases treated for defects other than teeth went to consult physicians and only 228 made use of dispensaries. The remaining 19 are not accounted for.

TABLE II

INDICATING PLACE OF TREATMENT, OF DEFECTS OTHER THAN TEETH, AS REPORTED ON SCHOOL CARDS.

| School | Total Number of Cases Treated | Treated by Physicians | Treated in Dispensaries |
|---|---|---|---|
| *School A:* lower East Side | 104 | 47 | 56 |
| *School B:* neighborhood of 30th St. and 2d Ave. | 88 | 41 | 45 |
| *School C:* uptown well-to-do district | 94 | 54 | 31 |
| *School D:* upper East Side | 196 | 93 | 96 |
| Totals | 482 | 235 | 228 |

TABLE III

INDICATING PLACE OF TREATMENT OF DEFECTIVE TEETH, AS REPORTED ON SCHOOL CARDS.

| School | Total Number of Cases Treated | Treated by Dentists | Treated in Dispensaries |
|---|---|---|---|
| *School A:* lower East Side | 90 | 75 | 8 |
| *School B:* neighborhood of 30th St. and 2d Ave. | 24 | 11 | 13 |
| *School C:* uptown well-to-do district | 75 | 48 | 3 |
| *School D:* upper East Side | 39 | 22 | 16 |
| Totals | 228 | 156 | 40 |

The same to a much greater degree is true of dental work. 156 private dentists were consulted as against 40 in the clinics. It is a remarkable showing, considering that three of the four schools are in the poor sections of the city. The conditions can be ascribed to the following three causes: (1) parents do not want to pauperize their children in taking them to free dispensaries; (2) people have not strong faith in the effectiveness of dispensary treatment; and (3) the hours of the dispensaries are in many instances not suited to the convenience of the children and, furthermore, going to a dispensary, under the present conditions of overcrowding, entails long hours of waiting.

All of the figures quoted in this inquiry must, of course, be taken with many grains of salt. The element of negligence and error on the part of the physicians and nurses making out the records must be taken into consideration. Then, the four schools selected out of a total of 513 public schools of the city of New York may not reflect prevailing conditions adequately. These considerations lead one to insist on the importance of a similar study on a large and comprehensive scale where the element of error would be minimized and the conditions in a majority of schools in all parts of the greater city analyzed. Meanwhile, the present fragmentary study tends to indicate: (first) that although the difference in the economic and educational status of the various classes of the population is a factor to be reckoned with in adopting measures leading to efficiency of medical inspection of school children, yet the average percentage of defects treated in children of parents in better circumstances and of an average higher level of education is not materially different, if at times not smaller, than in children of the poorer sections of the city: in this connection it must be noted that the per cent. of children with defects other than teeth was much lower in the well-to-do section than in any of the three other sections; (second) that full and harmonious cooperation between the teaching staff and the medical corps is an element of extreme import in the efficacy of the work. In some instances, especially in cases of defects with reference to which a great deal of popular education has been undertaken, it is evidently possible to attain one hundred per cent. of treatments when the cooperation of the principal and teachers is genuine and wholehearted; (third) that the proximity to the school of a well-equipped and efficient dispensary tends to increase the usefulness and efficiency of the work of the medical school inspectors; (fourth) that in the case of children's ailments, parents, even of the poorer classes, resort in fifty per cent. of cases to the services of private physicians; (fifth) that over thirty per cent. of reported treatments of school children by private physicians and dispensaries do not result in cure or improvement; and (sixth) that teeth are of all the largest and most neglected class of children's defects.

Should a comprehensive study on the lines suggested in this paper bear out the above cited conclusions a thorough revision of the underlying theory and methods of our medical school inspection should be undertaken and serious attention given to the institution and organization of school clinics where efficient, competent and prompt work would be done.

School clinics are being tried in various parts of the country and abroad. In New York City we have dental, nose and throat, and contagious eye diseases clinics for children, maintained by the Department of Health. The number of these clinics is small and their location is not planned to meet the peculiar needs of certain sections. The only therapeutic work done in schools of New York City is by nurses who treat minor skin and eye troubles like scabies, ringworm, favus, impetigo and conjunctivitis. This measure alone has decreased the number of school exclusions from 57,665 children in 1903 to 3,361 in 1911, but what is more important than mere school attendance, it has effected positive cure in thousands of cases.

It is my personal opinion and belief that school clinics, if adopted on a broader scale, should be established if not in every school, then in schools centrally located, so that children from other schools in the vicinity could easily reach them. The clinic districts should not be made too large, that the evils of overcrowding may be avoided and the children not subjected to waiting long and many hours. The treatment in school clinics for those who need it and are unable for one reason or another to secure the services of conscientious practitioners should be given not as a gratuity, but as a legitimate part of the functions of the school, just as a physical training or baths or recreation.

There will, no doubt, be opposition to them at first. We attempted once to enucleate tonsils in schools and we had street riots in the Italian section of the city. There will be other sources of opposition. Every new experiment or departure from established routine is bound to invite opposition, but as the clinics demonstrate their usefulness and efficiency, the opposition to them will gradually wane.

A number of sources has been suggested to secure the means necessary for the maintenance and operation of such clinics: budgetary provision by the municipality, special assessments, voluntary per capita contributions of a couple of cents weekly by the parents of the children, and, finally, the establishment of branches in school buildings by dispensaries caring to reach out. Each of these suggestions has its merits, but the last two may prove impractical. A system of collecting small contributions is cumbersome and costly, and establishing of children's clinics in schools by dispensaries is not very probable; furthermore, the extension of the field of the gratuitous service of the physician is impractical and unjust. Physicians must be paid for their work and paid adequately. If the establishment of school clinics proves to be a public need then, not one class or classes, but the community as a whole must defray the expense of their maintenance and operation.

# THE LABORATORY OF COMPARATIVE PATHOLOGY OF THE ZOOLOGICAL SOCIETY OF PHILADELPHIA

By R. W. SHUFELDT, M.D.

WASHINGTON, D. C.

IN various publications recently I have pointed out the fact as to how little is being done in the way of describing the anatomy of the existing Vertebrata of our fauna. One animal after another is now being exterminated with a rapidity never before equalled in the history of man, neither has there ever been a time in that history when so little was done to preserve detailed accounts, properly illustrated, of the comparative morphology of the species so doomed.

This state of things is not entirely confined to our own country by any means, for the same neglect is but too apparent elsewhere. Faunæ are being exterminated and material recklessly wasted at zoological gardens, laboratories and other places to an extent that is most deplorable. Comparative anatomists of the next century will be fully justified in saying what they please of such criminal neglect as this, when they come to realize the extent to which those of the present one ignored their opportunities in this field of scientific research, and allowed so many animals to die out without leaving the shadow of a record describing their structure.

We are doing much better with respect to the study of the causes of death in those ferine forms which die in captivity, for the activity along such lines is very marked and more or less universal. Not only are the diseases of the vertebrates below man being studied in numerous and fully equipped institutions in this country and abroad, but, through various scientific methods, comparative pathology, including that of man and the domesticated animals, is being investigated, studied and utilized in a manner far more extensive than has ever been the case in the history of our race. Such investigations include the parasites of the Vertebrata, a field of research which has received so much attention during recent years at the hands of Dr. F. E. Beddard, prosector of the Zoological Society of London, in the Old World, and Dr. Charles Wardell Stiles, of the Bureau of Animal Industry of this country.

Recently I have been in communication with Dr. Herbert Fox on this subject, and he has kindly placed at my disposal a set of photographs illustrating the building and the work rooms of the Laboratory of Comparative Pathology of the Zoological Society of Philadelphia, of which institution he is now the pathologist in charge. Dr. Fox has also

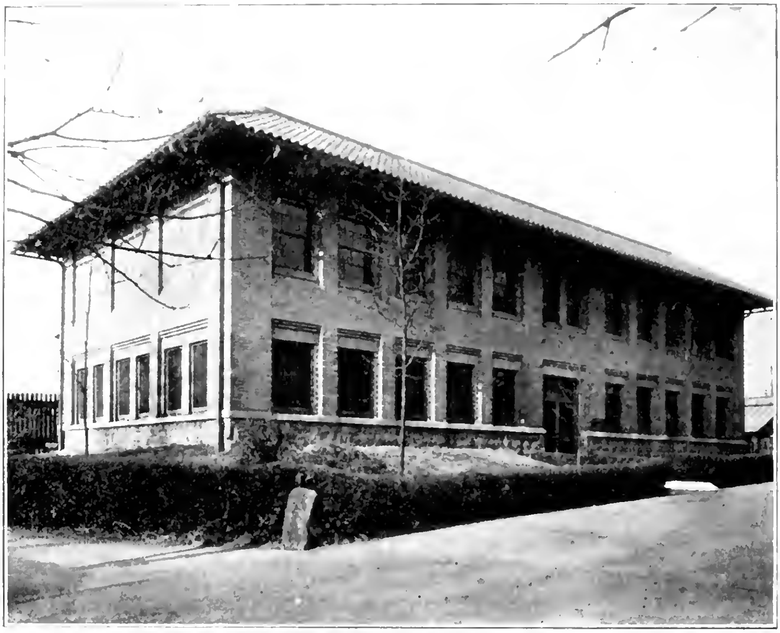


FIG. 1. EXTERIOR OF THE LABORATORY BUILDING OF COMPARATIVE PATHOLOGY OF THE ZOOLOGICAL SOCIETY OF PHILADELPHIA.

sent me some excellent photographs of pathological specimens prepared at his laboratory and obtained from animals which have died at the Philadelphia Zoological Garden. These are very instructive, indeed; but, much as I regret the fact, they can not well be used in the present connection.

It was in 1901 that pathological work upon the animals that died at the Zoo was inaugurated, and this at the instance of Dr. Charles B. Penrose, of Philadelphia, who had as advisers in the matter the late Dr. Leonard Pearson, of the Pennsylvania Veterinary Department, and Dr. M. P. Ravenel, of the State Stock Sanitary Board.

The first pathologist to the garden was Dr. C. Y. White, assistant director of the William Pepper Laboratory of Clinical Medicine, in which laboratory the post mortems were done.

We learn from the Thirty-first Annual Report of the Board of Directors of the Zoological Society (1903) that no fewer that seventy-six different species of mammals had there been examined with the view of ascertaining the cause of their death, and the result of the autopsies recorded (pp. 20–25). A large number of these mammals were various species of monkeys, apes and their allies (Primates), and the great majority of these succumbed to general tuberculosis.

Besides this much-dreaded malady, these animals suffered from twenty-five other diseases of which they were the victims; this does not

FIG. 2. GENERAL LABORATORY WORK-ROOM.

include the parasites observed, nor one bird—a cow bird—in which case molluscum contagiosum proved fatal. These examinations were made during the period from November, 1901, to March 1, 1903. Numerous other animals also died during this time of which no record was kept and no examination made; these were principally birds and indigenous species of mammals, reptiles and other forms. They died chiefly from the injuries and disturbances incident to their capture and captivity, most often shortly after reception, and, as a general thing, no special use was ever made of them.

Dr. Penrose reported that

In ten of the animals examined no cause of death was discovered, though careful investigation of all the organs was made, as well as bacteriological examination of the blood. Change in food, water, temperature and general environment, may cause the death of wild animals in captivity, without producing gross or apparent lesions of any of the structures of the body. It is probable that in some cases the animal dies of a toxæmia due to improper food, though we have been unable to determine the existence of this condition at autopsy. The *post mortem* changes have usually rendered the bacteriological examination very unsatisfactory.

These reports of Drs. Penrose and White, continuing until 1906, are of great interest and importance, but altogether too extensive even for summarization here.

In 1905 a building was selected upon the grounds of the garden and, at some expense, remodeled for a pathological laboratory, Dr.

FIG. 3. ONE OF THE QUARANTINE ROOMS.

Fox taking charge of this the following year (Fig. 1). As the operations of this department became more extensive, it was realized that the labor of no one man could properly compass it; therefore, in 1910, Dr. Fred D. Weidman, who at the time was assistant in the department of pathology at the University of Pennsylvania, received the appointment of assistant pathologist, and the following year a second floor was put upon the building to accommodate the museum specimens and for additional work-room.

From about this time on, the principal part of the report of the society was given over to that of the pathological laboratory, a most gratifying indication of the value of the work performed there. As evidence of this we find that the thirty-ninth annual report of the board of directors of the society (1911) prints forty-seven small octavo pages, and of these Dr. Fox's report of the laboratory occupies from pages 15 to 40 inclusive.

Far-reaching in its importance, this report contains most valuable data, which can not fail to be of use, not only to keepers of gardens and menageries, but to the human pathologist and the breeder of domestic animals. The report goes to show that no fewer than 325 animals were examined, of which number 93 were mammals. There is an excellent report on "Tuberculin Reaction in Monkeys" containing much of practical value, while what Dr. Weidman gives on "Parasites" is not only quite extensive, but presented in great detail. A valuable special report

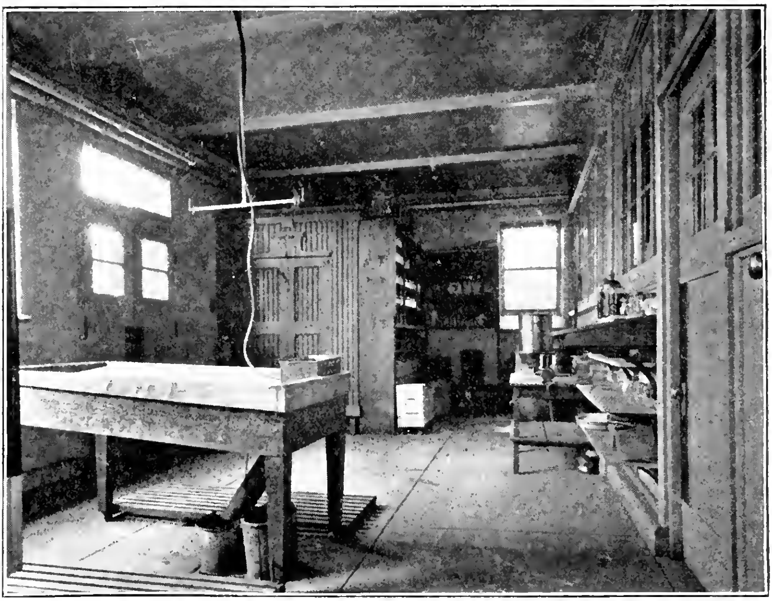


FIG. 4. AUTOPSY ROOM.

on "Bird Diphtheria" follows, with others on "Recurrent Ophthalmia," and one made by Drs. E. A. Schumann and Fox on "Leucocyte Counts."

All these are in evidence of the marked activity of this very efficient laboratory, and the character of the contributions we may expect from it in the future. Autopsies are performed on all the animals which die in the gardens, with the exception of the small reptiles. Dr. Fox says:

> The data concerning the animal during life is sent to the laboratory from the office on a special card form and the pathological findings are put upon this card. It is then used as a zoological index card and the diagnoses are cross indexed in a pathological system. Routine and special pathological and bacteriological methods are used as in the usual laboratory systems. The data obtained from these diagnoses is used in the hygiene of the garden and for scientific record.
>
> Included in the laboratory's work is the testing of animals suspected of having tuberculosis, a test made by subcutaneous injection of tuberculin. All monkeys received by the garden are observed for several days, and a record made of their daily 3 P.M. temperature. They are then tested, and if negative to this test are passed to the general monkey collection. If the test be doubtful, they are either held in quarantine or put on exhibition in isolated cages. If the test be positive they are killed. In order to avoid the carrying of tubercle bacilli on the hair they are washed in phenol solution upon arriving in and leaving the laboratory. Because of the frequent occurrence of proventricular worms in the parrots, the laboratory also examines the excrement of all new arrivals before they are put on exhibition.

This laboratory consists of an equipment of a two-floored building. We find on the first floor the general laboratory workroom (Fig. 2),

Fig. 5. Museum and Library (Second Floor).

fitted up for special experiments and investigations. On the same floor there are two quarantine rooms, one of which is here shown in Fig. 3, wherein are seen the cages in which are kept the animals under observation, or those presenting pathological conditions requiring their isolation. Beyond these we have the autopsy room, fitted out with all the modern appliances for performing post mortems.

In the case of three of these rooms, the walls are coated with hard paint, and center-drains are found in their concrete floors for the purpose of frequent flushing. One of the quarantine cages measures 27 × 24 × 20 inches and a larger one 29 × 36 × 30 inches, the top in any case being five feet from the floor. These comfortable quarters are of galvanized iron and fitted with a door which can not be opened by the animal.

Passing to the second floor of this building, we find it given over to a single room of considerable size, measuring thirty feet by sixty-nine. It is lighted overhead by a large, central skylight, while windows are only found in the north and east walls, the south and west ones being unpierced in any way to admit light. In this room is kept the collection of pathological specimens, some of which are from human subjects for the purposes of comparison. Many drawings, charts and photographs are upon the walls, while tables and desks are placed in convenient corners for the use of those doing clerical or laboratory desk work.

For the purpose of destroying the animal remains after autopsies and dissections, there is in the building a direct incinerating plant—a most important adjunct to an institution of this kind.

The personnel of this laboratory is not large, being at present confined to the pathologist, assistant pathologist, technical assistant and a diener.

Should it come to pass at any time later on that the pathological work now being prosecuted in this very efficient department of the Philadelphia garden be supplemented by similar researches upon normal anatomy, for the purpose of which plenty of material is constantly there at hand, it will become necessary to increase the number on the present staff by adding to it a duly qualified prosector, zoological artist, photographer, and one or two additional assistants. It is very much to be hoped that this will be brought about in the near future.

# THE PROGRESS OF SCIENCE

## *THE AMERICAN MUSEUM OF NATURAL HISTORY*

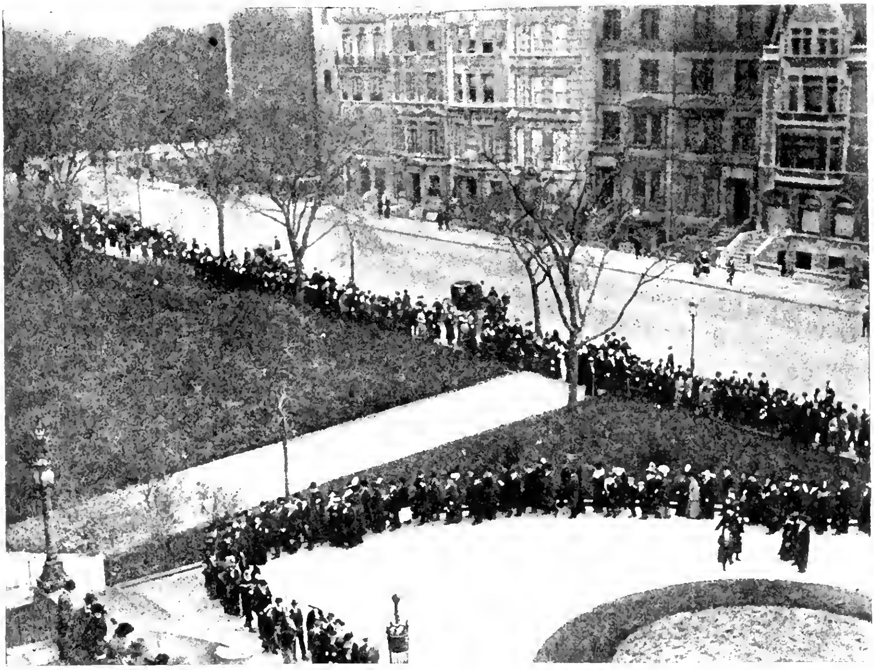
The extraordinary development of universities in the United States is paralleled by the growth of its museums. In Washington, New York, Chicago and Pittsburgh, four museums of natural history have in a comparatively brief period taken their places among the leading institutions of the world, and in many other cities there are important and growing museums. Many of these museums, like the universities, are interesting demonstrations of the possible achievements of a democracy. On the one hand, they are supported in almost equal measure by taxation and by private gifts, on the other hand, they are devoted not primarily to the preservation of stuffed animals, but to education, research and public service.

The forty-fifth annual report of the American Museum of Natural History in New York City illustrates these remarks. The city has provided land and buildings worth many million dollars and approved a plan of development of unexampled magnitude. The city also provided last year $200,000 for maintenance. Then for exploration, research and the increase of the collections about $250,000 accrued from private endowment and gifts. The annual gifts are about equal in amount from the trustees and from members and friends, who number some 3,500.

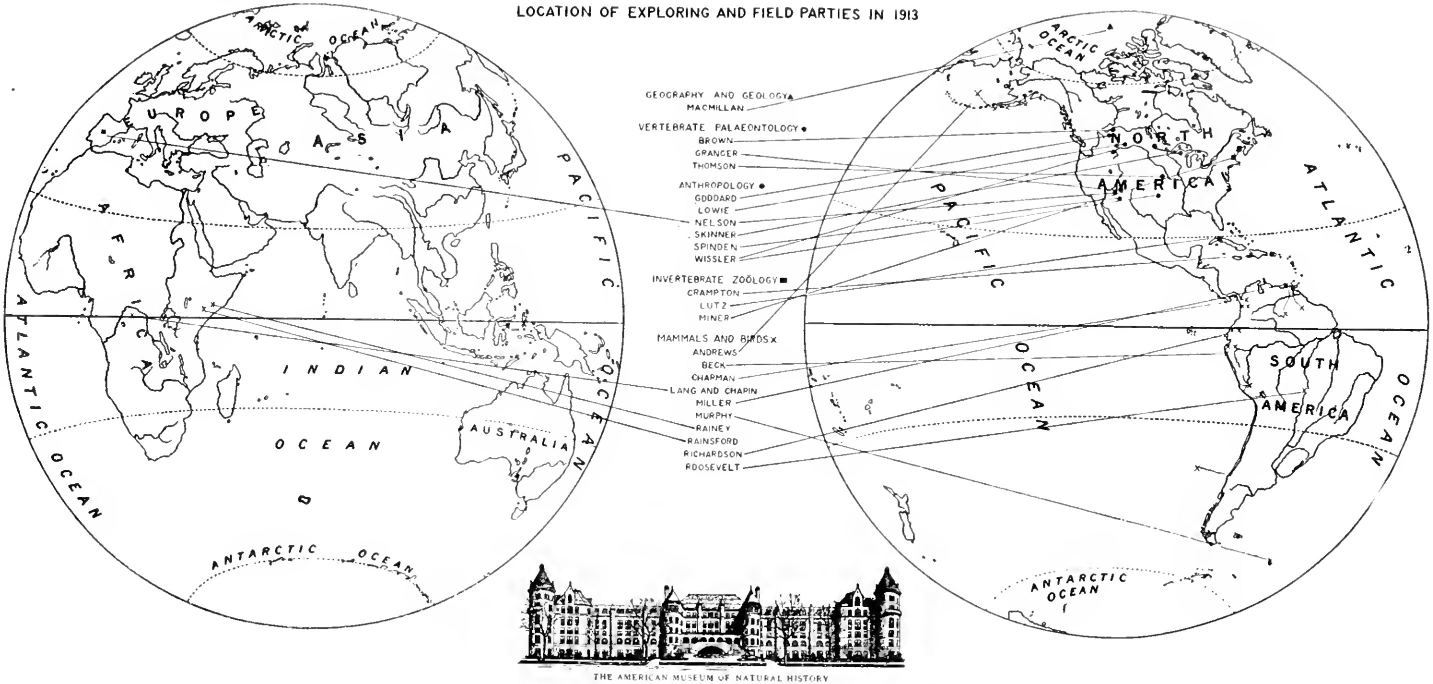
The illustrations here reproduced show the museum and its approaches, though it should not be assumed that such crowds enter the museum every day in the year. The total attendance in 1913 was 866,633, of whom 138,375 were primarily present for lectures and scientific meetings. Part of the attendance in the galleries was due to the flower exhibition of the Horticultural Society and other temporary exhibits, which Dr. Lucas, the director, holds do not result in any real profit to a museum. We should suppose, however, that while such exhibits and the large number of lectures and scientific meetings may not greatly increase interest in the natural history collections, they enlarge the functions of a museum in a desirable manner.

This holds still more for the expeditions and research work. As in the university the professor earns his salary by teaching but is expected to advance knowledge, so in the museum the curator must care for the display of the exhibits but he should also be engaged in scientific research. So long as society provides no way of paying directly for the results of investigations having no immediate commercial value, these must be undertaken by universities and scientific institutions. This should be regarded as part of their function, but in any case it is justified by the fact that the professor or curator will do the work of teaching or caring for collections better if he is encouraged to engage in research and publication, and under these circumstances better men can be secured for the positions.

Though the museum has been unfortunate in losing two of its most distinguished investigators, Professor Boas of Columbia University in anthropology and Professor Wheeler of Harvard University in invertebrate zoology, it produces each year an important series of contributions to scientific knowledge. Last year the sum of $25,000 was spent on publications, partly technical researches, of which Dr. D. G. Elliot's "A Review of the Primates" is the most noteworthy, and partly on popular publications, including the excellent "Museum Journal."



Visitors Entering the American Museum of Natural History.




MAP OF THE WORLD.

The report of the president, Dr. Osborn, reviews the general progress of the work of the museum, noting the establishment of a contributory pension system, according to which the employee contributes to the fund three per cent. of his salary and the trustees provide an equal amount. Among installations, the collection of bronzes made in China by Dr. Laufer is especially noted. Gifts include the Mason archeological collection from Tennessee by the late Mr. J. P. Morgan, the Angelo Heilprin Exploring Fund, established by Mr. and Mrs. Paul J. Sachs, and numerous specimens from individuals and institutions.

The museum, however, must depend for its most valuable accessions on its own expeditions. The number and range of these expeditions in 1913 are shown on the chart. The expedition to Crocker Land, under Mr. McMillan, suffered from the stranding of the *Diana*, but has proceeded to the Arctic regions. Expeditions to the north in search of bowhead whales and to the south to secure the nearly extinct sea elephant were not successful, but other material was obtained including motion pictures of the life on the seal islands. The paleontological and ethnological expeditions in the west from which important collections and researches have resulted were continued. In South America Mr. Chapman and others have made ornithological surveys and collections, and the present expedition of Mr. Roosevelt is under the auspices of the museum. Africa has been explored by Messrs. Lang, Chapin, Rainsford and Rainey. Dr. Osborn, the president, has visited the French prehistoric caverns. Such expeditions not only increase in the most desirable way the collections of a museum, but also contribute in large measure to the advancement of science.

### *THE MARVELS OF SCIENCE*

It would perhaps be worth while to issue a number of The Popular Science Monthly consisting entirely of articles sent in by those who in Bishop Berkeley's phrase are "undebauched by learning." At first sight it might seem disquieting that there are so many people in the United States without the slightest training or appreciation of scientific methods who would like to publish their views on electricity, gravity, the ice age and similar topics, or have them endowed by the Carnegie Institution. But we may in fact regard it as a not altogether unsatisfactory symptom of universal education in a democracy, and of growing interest in science. The pseudo-science often exhibited in our daily papers and legislative halls will surely be eliminated by a comparatively small increase in education and the control of public sentiment by those who know, and we may then look to a notable advance in scientific research through the rewards and opportunities which a discriminating public would be able to bestow.

While it might be unfair to print some of the contributions sent in, it may not be amiss to quote two paragraphs which have just now been brought to our attention. The first is from a speech in the House of Representatives by Mr. Hobson of Alabama, which is being widely circulated under the congressional franking privilege. He said:

> The last word of science, after exact research in all the domains, is that alcohol is a poison. It has been found to be a hydrocarbon of the formula $C_2H_6O$, that is produced by the process of fermentation, and is the toxin or liquid excretion or waste product of the yeast or ferment germ. According to the universal law of biology that the toxin of one form of life is a poison to all forms of life of a higher alcohol, the toxin of the low yeast germ, is a protoplasmic poison to all life, whether plant, animal or man, and to all the living tissues and organs.
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> * * * * * * *
>
> After long continued drinking, even though temperate, the microscope shows that the white blood corpuscles, with the serum which contains their vegetable food continually sucked up by the dehydrating toxin, become carnivorous, and begin to feed upon the tissues and organs, like disease germs. The favorite tissue food of

the degenerate corpuscles are the tender cells of latest development. In the human being the latest development is the brain. The microscope shows the degenerate corpuscles, with the goods upon them, down in their bodies the gray matter of the brain. This accounts for the tremendous mortality among heavy drinkers and for the degeneracy that will be referred to later.

The second quotation, the head-lines and editorial from the April publications of a Sunday newspaper syndicate, is as follows:

## WHEN THE WORLD'S BACK BROKE

### By James Oliver Curwood

Illustrated by

Charles Livingston Bull

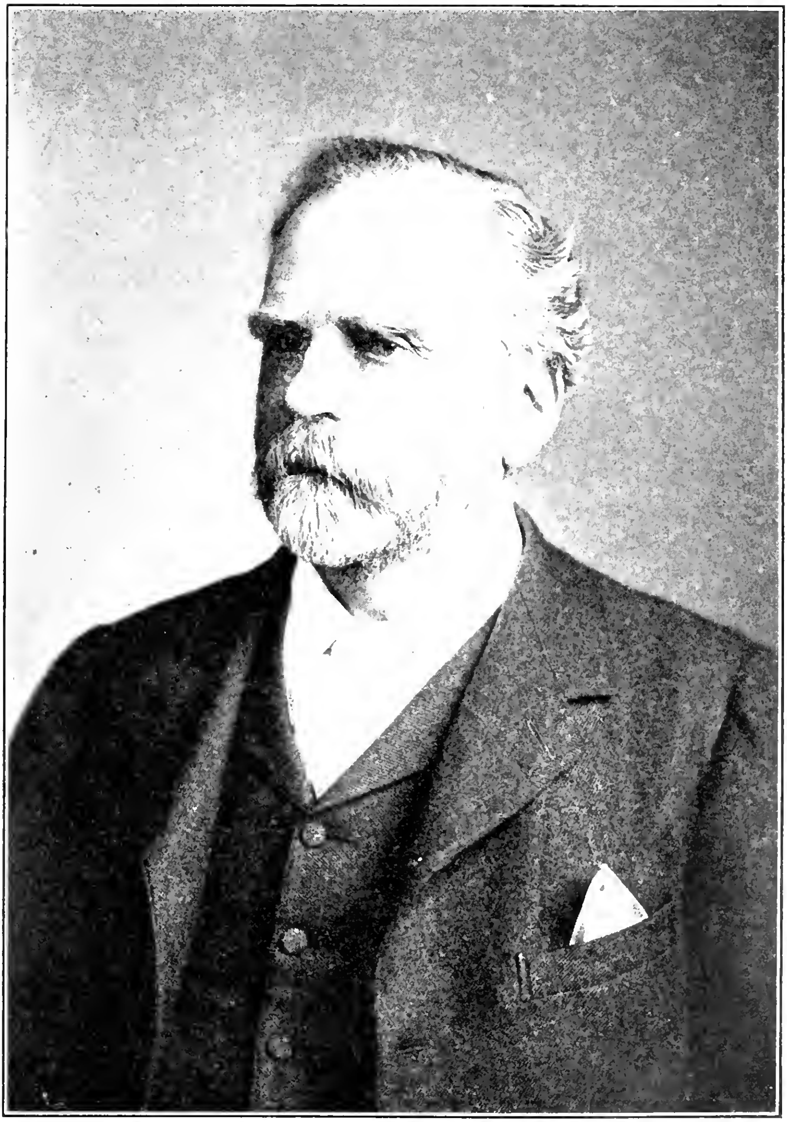
*EDITOR'S NOTE.—Mr. Curwood is the first writer to tell in fiction the dramatic story of that day, thousands of years ago, when in the space of what was probably no more than a few minutes the earth tilted twenty-three and a half degrees on its axis, transforming what was then a tropical world into the blackness of a night which lasted for unnumbered centuries, and out of which came what are known as the North Polar regions of today. In that one "first night" of a life that had known only perpetual day all living creatures perished; but entombed in their caskets of ice and frozen earth many of them have come down to us fifty or a hundred thousand years later, so completely preserved that the flesh of mastodons recently discovered was eaten by dogs and men. In fact, Mr. Curwood helped uncover a mastodon at Fort Migley and ate of the flesh.*

## QUARANTINE OF HAWAIIAN FRUIT

THE office of information of the Department of Agriculture has sent out a notice in regard to the stringent regulations which have been adopted to guard against danger from the melon fly and the Mediterranean fruit fly. Any one who attempts after May 1, to bring into the United States certain Hawaiian fruits, nuts and vegetables will face a penalty of $500 fine or imprisonment for a year or both. A new order issued by the Department of Agriculture provides this punishment for attempts to violate the quarantine declared in 1912, under the plants quarantine act, against Hawaiian products which might introduce into the United States two dangerous pests, the melon fly and the Mediterranean fruit fly. Under the new regulations importations of bananas and pineapples are permitted under stringent conditions of inspection and certification. Practically all other fruits and such vegetables as tomatoes, squashes, green peppers and string beans are absolutely excluded. Circulars are to be distributed on all incoming steamships warning passengers of the quarantine and the reason for it.

Hitherto the United States has fortunately been free from both the melon fly and the Mediterranean fruit fly. The latter in particular has proved a source of great loss, practically putting an end to the fruit industry wherever it has obtained a good foothold. The Bermuda peach crop, for instance, is now a thing of the past. It is believed to have originated on the west coast of Africa, its name being due to the great damage it did after it had been carried to the Mediterranean. It also spread to Bermuda, South Africa, Australia and New Zealand, whence it was carried in ships' cargoes to Hawaii. In all probability the fly would be in California to-day if it were not for the fact that no fruit is grown in the immediate vicinity of San Francisco. The great danger is that some traveler may unknowingly bring with him as a curiosity pest-infected fruit, nuts or vegetables and introduce them into a region favorable for the fly's spread.

Commercially the quarantine will not seriously interfere with Hawaiian industries. Bananas and pineapples, the only fruits which are grown in the island in commercial quantities, do not, as a rule, carry the infection. When properly inspected and packed in accordance with the department's regulations, they will, therefore, be allowed admission. Other fruits, such as alligator pears, Chinese ink berries,



The Late Sir John Murray,
the distinguished Scottish oceanographer.

figs, guavas, papayas, etc., are far more dangerous. They have, however, little commercial importance. If they are taken on board at all, they must either be consumed or thrown overboard before the ship reaches the United States.

## SCIENTIFIC ITEMS

We record with regret the deaths of Dr. Edward Singleton Holden, astronomer and librarian of the United States Naval Academy, formerly director of the Lick Observatory; of Mr. George Westinghouse, the distinguished inventor and engineer; of Dr. Alexander F. Chamberlain, professor of anthropology at Clark University; of Adolph Francis Alphonse Bandelier, an authority on South American archeology, lecturer in Columbia University, and of Dr. John Henry Poynting, professor of physics at Birmingham University.

A portrait of Sir William Ramsay, painted by Mr. Mark Milbanke, has been presented to University College, London, by former colleagues and past students. Professor J. Norman Collie made the address. A replica of the portrait has been presented to Lady Ramsay.

The former students of Dr. J. McKeen Cattell, professor of psychology in Columbia University, at a dinner held in New York on April 8, presented him, in celebration of his completion of twenty-five years as professor of psychology, with a "Festschrift" in the form of reviews of his researches and of the work in psychology to which they have led. On April 6, 7 and 8, there was held at Columbia University a Conference on Individual Psychology by former students of the department of psychology, at which thirty papers were presented.

The Rockefeller Institute for Medical Research, New York, announces that it has received from Mr. John D. Rockefeller an additional endowment of $1,000,000 for the purpose of organizing a department for the study of animal diseases. A gift of $50,000 has also been received from Mr. James J. Hill, for the study of hog cholera.

Following the disastrous fire at Wellesley College the General Education Board has promised to give $750,000 to the college on condition that the balance of the $2,000,000 restoration and endowment fund is completed by January 1, 1915.

Mr. Andrew Carnegie has given $100,000 to the New York Zoological Society to provide a pension fund for the New York Zoological Park and the Aquarium. The scientific staff and the employees will contribute annually 2 per cent. of their salaries, and any sum that may be lacking will be made up by the Zoological Society.

As has already been noted in *Science*, the American Chemical Society held its spring meeting at Cincinnati, Ohio, during the week of April 6. Each of the sections had a full and important program. At the general session on the first day, after addresses of welcome by the mayor of the city and the president of the University of Cincinnati, and a reply by the president of the society, Professor Theodore W. Richards, the following papers were announced: Arthur L. Day, "The Chemical Problems of an Active Volcano"; L. J. Henderson, "The Chemical Fitness of the World for Life"; W. D. Bancroft, "Flame Reactions"; Irving Langmuir, "Chemical Reactions at Low Pressures."

# THE POPULAR SCIENCE MONTHLY

JUNE, 1914


## FACTS AND FACTORS OF DEVELOPMENT[1]


By Professor EDWIN GRANT CONKLIN

PRINCETON UNIVERSITY


### Introduction

ONE of the greatest results of the doctrine of organic evolution has been the determination of man's place in nature. For many centuries it has been known that in bodily structures man is an animal—that he is born, nourished and developed, that he matures, reproduces and dies just as does the humblest animal or plant. For centuries it has been known that man belongs to that group of animals which have backbones, the vertebrates, to that class which have hair and suckle their young, the mammals, and to that order which have grasping hands, flat nails, and thoracic mammæ, the primates, which group includes also the monkeys and apes. But as long as it was supposed that every species was distinct in its origin from every other one, and that each arose by a special divine fiat, it was possible to maintain that man was absolutely distinct from the rest of the animal world, and that he had no kinship to the beasts, though undoubtedly he was made in their bodily image. But with the establishment of the doctrine of organic evolution this resemblance between man and the lower animals has come to have a new significance. The almost universal acceptance of this doctrine by scientific men, the many undoubted resemblances between man and the lower animals, and the discovery of the remains of lower types of man, real "missing links," has inevitably led to the conclusion that man also is a product of evolution, that he is a part of the great world of living things and not a being who stands apart in solitary grandeur in some isolated sphere.

But wholly aside from the doctrine of evolution, the fact that essential and fundamental resemblances exist among all kinds of organisms can not fail to impress thoughtful men. The great life processes are everywhere the same in principles, though varying greatly in details.

[1] First of the Norman W. Harris Lectures for 1914 at Northwestern University on "Heredity and Environment in the Development of Men"; to be published by the Princeton University Press.

All the general laws of life which apply to animals and plants apply also to man. This is no mere logical inference from the doctrine of evolution, but a fact which has been established by countless observations and experiments. The essential oneness of all life gives a direct human interest to all living things. If "the proper study of mankind is man," the proper study of man is the lower organisms in which life processes are reduced to their simplest terms, and where alone they may be subjected to conditions of rigid experimentation. Upon this fundamental likeness in the life processes of man and other animals is based the wonderful work in experimental medicine, which may be counted among the greatest of all the achievements of science.

The experimental study of heredity, development and evolution in forms of life below man must certainly increase our knowledge of and our control over these processes in the human race. If human heredity, development and evolution may be controlled to even a slight extent, we may expect that sooner or later the human race will be changed for the better. At least no other scheme of social betterment and race improvement can compare for thoroughness, permanency of effect, and certainty of results, with that which attempts to change the natures of men and to establish in the blood the qualities which are desired. We hear much nowadays about man's control over nature, though in no single instance has man ever changed any law or principle of nature. What man can do is to put himself into such relations to natural phenomena that he may profit by them, and all that can be done toward the improvement of the human race is to consciously apply to man those great principles of development and evolution which have been operating unknown to man through all the ages.

## Phenomena of Development

One of the greatest and most far-reaching themes which has ever occupied the minds of men is the problem of development. Whether it be the development of an animal from an egg, of a race or species from a preexisting one, or of the body, mind and institutions of man, this problem is everywhere much the same in fundamental principles, and knowledge gained in one of these fields must be of value in each of the others. Ontogeny and phylogeny are not wholly distinct phenomena, but are only two aspects of the one general process of organic development. The evolution of races and of species is sufficiently rare and unfamiliar to attract much attention and serious thought; while the development of an individual is a phenomenon of such universal occurrence that it is taken as a matter of course by most people—something so evident that it seems to require no explanation; but familiarity with the fact of development does not remove the mystery which lies back of it, though it may make plain many of the processes concerned. The development of a human being, of a personality, from a germ cell is the climax of all wonders—greater even than that involved in the evolution of a species or in the making of a world.

The fact of development is everywhere apparent; its principal steps or stages are known for thousands of animals and plants; even the precise manner of development and its factors or causes are being successfully explored. Let us briefly review some of the principal events in the development of animals, and particularly of man, and then consider some of the chief factors and processes of development. Most of our knowledge in this field is based upon a study of the development of animals below man, but enough is now known of human development to show that in all essential respects it resembles that of other animals, and that the problems of heredity and differentiation are fundamentally the same in man as in other animals.

## I. Development of the Body

The entire individual—structures and functions, body and mind—develops as a single indivisible unity, but for the sake of clarity it is desirable to deal with one aspect of the individual at a time. For this reason we shall consider first the development of the body, and then the development of the mind.

1. *The Germ Cells.*—In practically all animals and plants individual development begins with the fertilization of a female sex cell, or egg, by a male sex cell, or spermatozoon. The epigram of Harvey, "Omne vivum ex ovo," has found abundant confirmation in all later studies. Both egg and spermatozoon are alive and manifest all the general properties of living things. How little this fact is appreciated by the public is shown by the repeated announcements by the newspapers that "Professor So-and-so has created life because he has made an egg develop without fertilization." An egg or a spermatozoon is as much alive as is any other cell—as characteristically alive as is the adult animal into which it develops. It is difficult to define life, as it is also to define matter, energy, electricity, or any other fundamental phenomenon, but it is possible to describe in general terms what living things are and what they do. Every living thing whatever, from the smallest and simplest microorganism to the largest and most complex animal, from the microscopic egg or spermatozoon to the adult man, manifests the following distinctive properties:—

1. It contains protoplasm, "the material basis of life," which is composed of the most complex substances known to chemistry. Protoplasm is not a homogeneous substance, but it always exists in the form of cells, which are minute masses of protoplasm composed of many distinct parts, the most important of these being the nucleus and the cytoplasm (Fig. 1). Protoplasm is therefore organized, that is, composed of many parts all of which are integrated into a single system, the cell. Higher animals and plants are composed of multitudes of cells, differing more

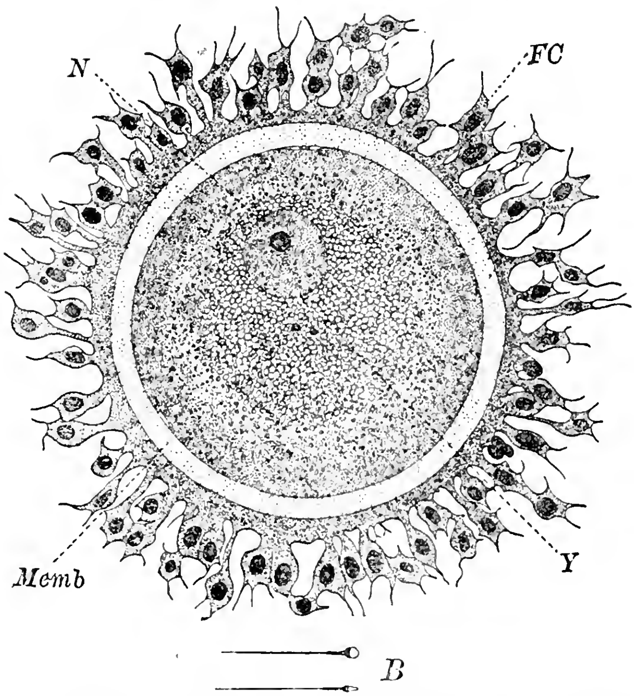



FIG. 1. A nearly ripe human ovum in the living condition. The ovum is surrounded by a series of follicle cells (*FC*) inside of which is the clear membrane (*Memb.*) and within this is the ovum proper containing yolk granules (*Y*) and a nucleus (*N*) embedded in a clear mass of protoplasm. Magnified 500 diameters (× 500). (From O. Hertwig.) *B*, two human spermatozoa drawn to about the same scale of magnification. (After G. Retzius).

or less from one another, which are bound together and integrated into a single organism. Living cells and organisms are not static structures which are fixed and stable in character, but they are systems which are undergoing continual change. They are like the river, or the whirlpool, or the flame, which are never at two consecutive moments composed of the same particles but which nevertheless maintain a constant general appearance; in short they are complex systems in dynamical equilibrium.

The principal physiological processes by which all living things maintain this equilibrium are:

2. Metabolism, or the transformation of matter and energy within the living thing, in the course of which some substances are oxidized into waste products, with the liberation of energy, while other substances are built up into protoplasm, each part of the cell converting food substances into its own particular substance by the process of assimilation.

3. Reproduction, or the capacity of organisms to give rise to new organisms, of cells to give rise to other cells, and of parts of cells to give rise to similar parts by the process of division.

4 Irritability, or the capacity of receiving and responding to im-

pinging energies, or stimuli, in a manner which is usually, but not invariably, adaptive or useful.

Both the egg and the sperm are living cells with typical cell structures and functions, but with none of the parts of the mature organism into which they may develop. But although they do not contain any of the differentiated structures and functions of the developed organism, they differ from other cells in that they are capable under suitable conditions of producing these structures and functions by the process of development or differentiation, in the course of which the general structures and functions of the germ cells are converted into the specific structures and functions of the mature animal or plant.

In both plants and animals the sex cells are fundamentally alike, though they differ greatly in appearances. The female sex cells of flowering plants are called ovules, the male cells pollen. The corresponding cells of animals are known as ova and spermatozoa. Collectively all kinds of sex cells are called gametes, and the individual formed by the union of a male and female gamete is known as a zygote, while the cell formed by the union of egg and sperm is frequently called the oosperm.

The egg cell of animals is usually spherical in form and contains more or less food substance in the form of yolk; it varies greatly in size, depending chiefly upon the quantity of yolk, from the great egg of a bird, in which the yolk, or egg proper, may be hundreds of millimeters in diameter, to the miscroscopic eggs of oysters and worms, which may be no more than a few thousandths of a millimeter in diameter. The human ovum is microscopic in size (about 0.2 mm. in diameter) but it is not smaller than is found in many other animals. It has all the characteristic parts of any egg cell, and can not be distinguished microscopically from the eggs of several other mammals, yet there is no doubt that the ova of each species differ from those of every other species, and later we shall see reasons for concluding that the ova produced by each individual are different from those produced by any other individual.

The sperm, or male gamete, is among the smallest of all cells and is usually many thousands of times smaller than the egg. In most animals, and in all vertebrates, it is an elongated, thread-like cell with an enlarged head which contains the nucleus, a smaller middle-piece, and a very long and slender tail or flagellum, by the lashing of which the spermatozoon swims forward in the jerking fashion characteristic of many monads or flagellated protozoa. In different species of animals the spermatozoa often differ in size and appearance, and there is every reason to believe that the spermatozoa of each species are peculiar in certain respects even though we may not be able to distinguish any structural differences under the microscope. The human spermatozoa closely resemble those of other primates but are still slightly different, and the conclusion is inevitable, as we shall see later, that the spermatozoa as well as the ova of each individual differ slightly from those of every other individual.

2. *Fertilization.*—If a spermatozoon in its swimming comes into contact with a ripe but unfertilized egg, the head and middle-piece of the sperm sink into the egg while the tail is usually broken off and left outside. The nucleus in the head of the sperm then begins to absorb material from the egg and to grow in size and at the same time a minute granule, the centrosome, appears, either from the middle-piece or

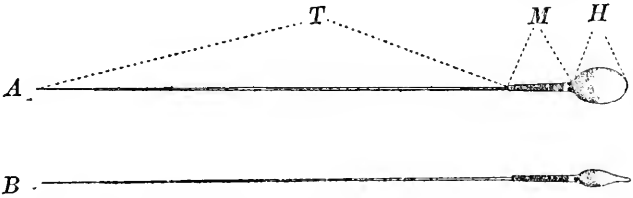



FIG. 2. TWO HUMAN SPERMATOZOA. *A*, showing the surface of the flattened head; *B*, its edge; *H*, head; *M*, middle piece; *T*, tail. (After G. Retzius.)

from the head of the sperm, and radiating lines run out from the centrosome into the substance of the egg. The sperm nucleus and centrosome then approach the egg nucleus and ultimately the two nuclei come to lie side by side. Usually when one spermatozoon has entered an egg all others are barred from entering, probably by some change in the chemical substances given out by the egg.

This union of a single spermatozoon with an egg is known as fertilization. Whereas egg cells are usually, but not invariably, incapable of development without fertilization, there begins, immediately after fertilization, a long series of transformations and differentiations of the fertilized egg which leads to the development of a complex animal—of a person. In the fusion of the egg and sperm cells a new individual, the oosperm, comes into being. The oosperm, formed by the union of the two sex cells, is really a double cell, since parts of the egg and sperm never lose their identity, and the individual which develops from this oosperm is a double being; even in the adult man this double nature, caused by the union of egg and sperm, is never lost.

In by far the larger number of animal species the oosperm, either just before or shortly after fertilization, is set free to begin its own individual existence, and in such cases it is perfectly clear that the fertilization of the egg marks the beginning of the new individual. But in practically every class of animals there are some species in which the fertilized egg is retained within the body of the mother for a varying period during which development is proceeding. In such cases it is not quite so evident that the new individual comes into being with the fertilization of the egg—rather the moment of birth or the separation from the mother is generally looked upon as the beginning of the individual existence. And yet in all cases the egg or embryo is always distinguishable from the body of the mother and there is no protoplasmic connection between the two. In mammals generally, including also the human species, not a strand of protoplasm, not a nerve fiber, not a blood vessel passes over from the mother to the embryo; the latter is from the moment of fertilization of the egg a distinct individual with particular individual characteristics, and this is just as true of viviparous animals

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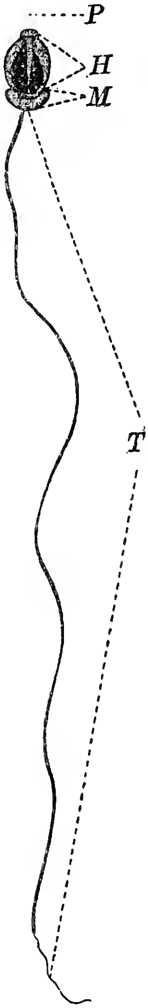


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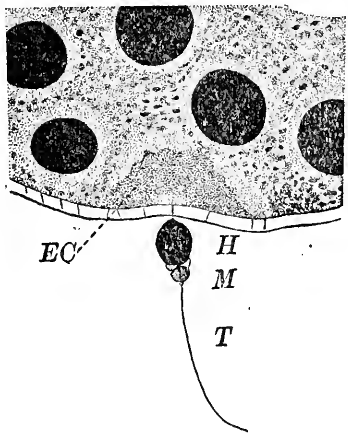


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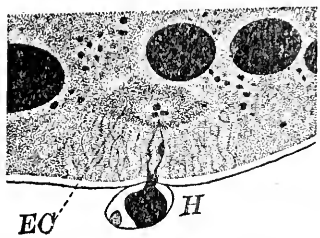
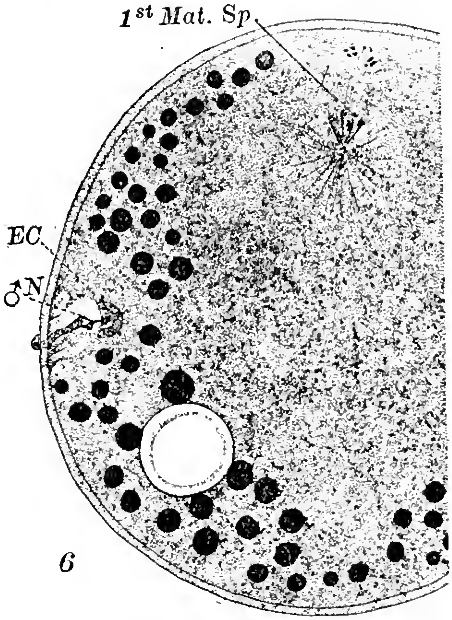


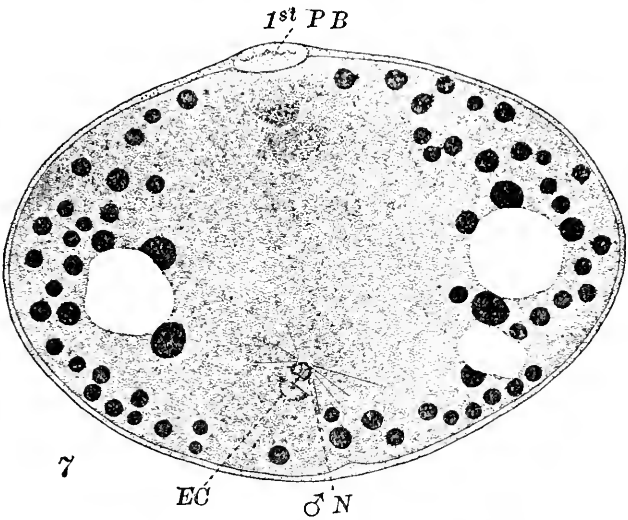

FIG. 3. ENTIRE SPERMATOZOON OF THE ANNELID *Nereis*, showing perforatorium (*P*); head (*H*); middle piece (*M*), and tail (*T*). (From F. R. Lillie.)

FIGS. 4-5. TWO STAGES IN THE ENTRANCE OF THE SPERMATOZOON INTO THE EGG OF *Nereis*. Some of the protoplasm of the egg has gathered at the point of entrance to form the entrance cone (*EC*) which, together with the sperm head, moves into the interior of the egg in later stages. The black spheres represent yolk. (From F. R. Lillie.)

in which the egg undergoes a part of its development within the body of the mother, as it is of oviparous forms in which the eggs are laid before development begins.

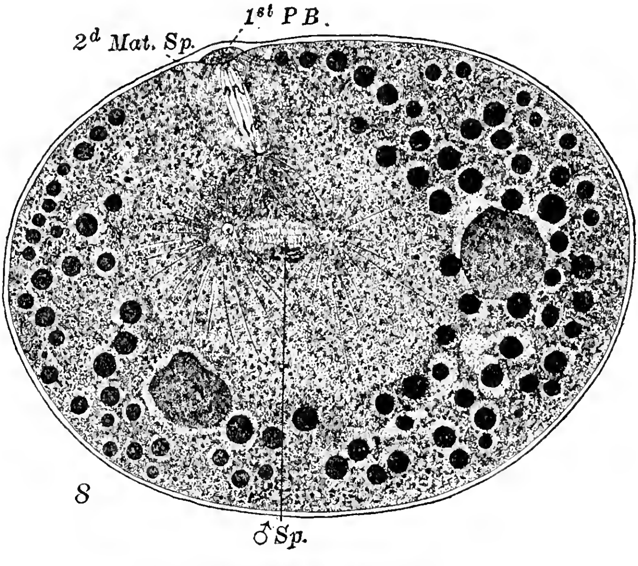
The fertilized egg of a star-fish, or frog, or man is not a different individual from the adults of these forms, rather it is a star-fish, a frog, or a human being in the one-celled stage, and thereafter this new being




FIGS. 6-9. SUCCESSIVE STAGES IN THE MATURATION AND FERTILIZATION OF THE entrance cone (*EC*) and sperm nucleus (♂N) into the egg. Fig. 6 shows the first ma- formed by this division; Fig. 8, the second maturation spindle (*2d Mat. Sp.*) and the in the first cleavage spindle (*1st Cl. Sp.*). (From F. R. Lillie.)

maintains its own individuality. This fertilized egg fuses with no other cells, it takes into itself no living substance from without, but manufactures its own protoplasm from food substances; it receives food and oxygen from without and it gives out carbonic acid and other waste products; it is sensitive to certain alterations in the environment such as thermal, chemical and electrical changes—it is, in short, a distinct living thing, an individuality. Under proper environmental conditions this fertilized egg cell develops, step by step, without the addition of anything from without except food, water, oxygen, and such other raw materials as are necessary to the life of any adult animal, into the immensely complex body of a star-fish, a frog, or a man. At the same time from the relatively simple reactions and activities of the fertilized egg there develops, step by step, without the addition of anything from without except raw materials and environmental stimuli, the multifarious

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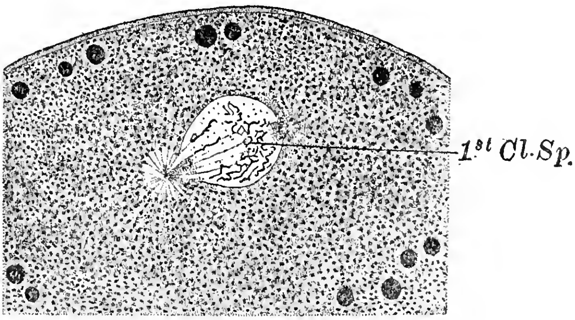


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Egg of *Nereis*, less highly magnified than Figs. 4 and 5, showing the progress of the turation spindle of the egg (*1st Mat. Sp.*); Fig. 7, the first polar body (*1st PB*) sperm nucleus and spindle (♂*N*); Fig. 9, the division of the male and female nuclei activities, reactions, instincts, habits, and intelligence of the mature animal.

Is not this miracle of development more wonderful than any possible miracle of creation? And yet as one watches this marvellous process by which the fertilized egg grows into the embryo, and this into the adult, each step appears relatively simple, each perceptible change is minute; but the changes are innumerable and unceasing and in the end they accomplish this miracle of transforming the fertilized egg cell into the fish, or frog, or man—a thing which would be incredible were it not for the fact that it has been seen by hundreds of observers and can be verified at any time by those who will take the trouble to study the process for themselves.

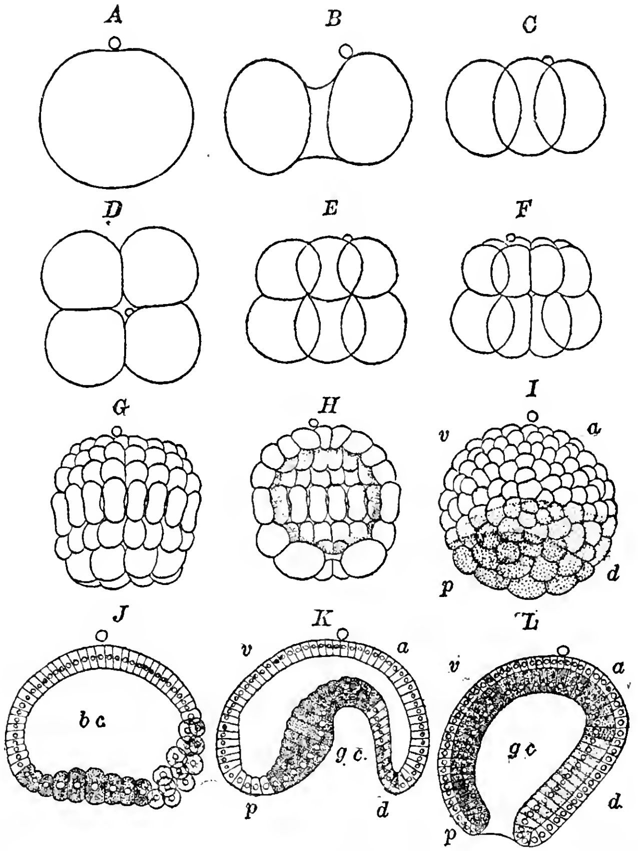


FIG. 10. SUCCESSIVE STAGES IN THE CLEAVAGE AND GASTRULATION OF *Amphioxus*. *A*, one cell; *B*, two cells; *C* and *D*, four cells; *E*, eight cells; *F*, sixteen cells; *G*, blastula stage of about ninety-six cells; *H*, section through the same showing the cleavage cavity; *I*, blastula seen from the left side showing three zones of cells, viz., an upper clear zone of ectoderm, a middle (faintly shaded) zone of mesoderm and a lower (deeply shaded) zone of entoderm cells; *J*, section through the same showing these three types of cells; *K* and *L*, successive stages in the gastrulation; cells indicated as in the preceding figure. In all figures except *D* the polar body is shown at the upper pole. Figs. *A–H* after Hatschek; Figs. *I–L* after Korschelt and Heider and Cerfontain. *a*, anterior; *p*, posterior; *v*, ventral; *d*, dorsal; *bc*, blastocœl; *gc*, gastrocœl.

3. *Cleavage.*—When the two germ nuclei (egg nucleus and sperm nucleus) have come into contact after the fertilization of the egg they divide by a complicated process known as mitosis, or indirect nuclear division (Fig. 9). The centrosome, which usually accompanies the sperm nucleus in its passage through the egg, divides and forms a spindle-shaped figure with astral radiations at its two poles (Figs. 7, 8). The chromatin, or stainable substance, of the nucleus, takes the form of threads, the chromosomes (Fig. 9), of which there is a constant number for each species of animal and plant. Each chromosome then splits lengthwise, its two halves moving to opposite ends of the spindle, in which position the daughter chromosomes fuse together to form the daughter nuclei. In this way the chromatin of the egg and sperm nuclei is exactly halved.

After the germ nuclei have divided in this manner the entire egg divides by a process of constriction into two cells (Figs, 10, 28). This is the beginning of a long series of cell divisions, each of them essentially like the first, by which the egg is subdivided successively into a constantly increasing number of cells. During the earlier divisions there

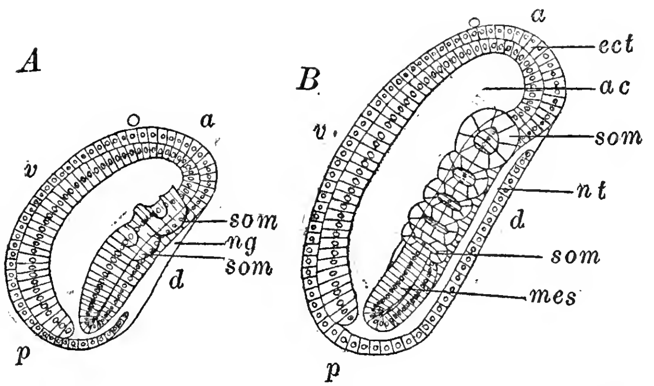


FIG. 11, *A* and *B*. TWO LATER STAGES IN THE DEVELOPMENT OF *Amphioxus*, showing the elongation of the embryo in the antero-posterior axis (*a p*), and formation of the somites (*som*); neural groove (*ng*) and neural tube (*nt*); *ect*, ectoderm; *ent*, entoderm; *mes*, mesoderm; *ac*, alimentary canal. (After Hatschek.)

is little or no increase in the volume of the egg, consequently successive generations of cells continually grow smaller (Figs. 10, 13, 14, *A*). This process is known as the cleavage of the egg, and by it the egg is not only split up into a considerable number of small cells, but a much more important result is that the different kinds of protoplasm in the egg become isolated in different cleavage cells, so that these substances can no longer freely commingle. The cleavage cells, in short, come to contain different kinds of stubstance, and thus to differ from one another. The differentiations of the cleavage cells appear much earlier in some forms than in others, but in all cases such differentiations appear during cleavage.

4. *Embryogeny.*—From this stage onward the course of development

differs in different classes of animals to such an extent that it is difficult to formulate any general description which will apply to all of them. Usually the many cleavage cells form a hollow sphere, the blastula (Fig. 10, *K*), and this in turn becomes a gastrula (Fig. 10, *L, M*), in which at first two, and later three, groups or layers of cells may be recognized; the outer layer, which is formed from cells nearest the animal pole of the egg, is the ectoderm; the inner layer, or entoderm, is formed from cells nearest the vegetative pole; a middle layer, or group of cells, the mesoderm, is formed from cleavage cells which in vertebrates lie between the animal and vegetative poles.

5. *Organogeny.*—By further differentiation of the cells of these layers and by dissimilar growth and folding of the layers themselves the various organs of the embryo begin to appear. From the ectoderm is formed the outer layer of the skin and the nervous system; from the entoderm arises the lining of the alimentary canal and its outgrowths; from the mesoderm comes, in whole or in part, the skeletal, muscular, vascular, excretory, and reproductive systems. In vertebrates the nervous system appears as a plate of rather large ectoderm cells (Fig. 12);

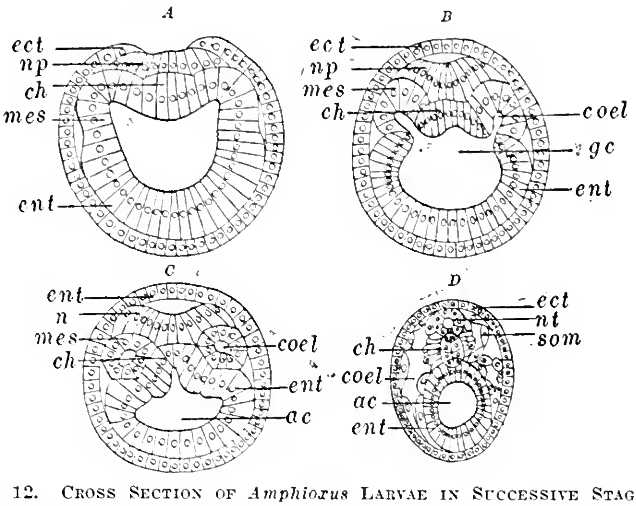


Fig. 12. Cross Section of *Amphioxus* Larvae in Successive Stages of Development. *A*, through a larva similar to 11*A*; *B* and *C*, of a larva similar to 11*B*; *D*, of a still older larva; *ect*, ectoderm; *ent*, entoderm; *mes*, mesoderm; *ch*, notochord; *np*, neural plate; *gc*, gastrocœl; *ac*, alimentary canal; *cœl*, cœlom.

this plate rolls up at its sides to form a groove (Fig. 12) and then a tube (Fig. 12); and by enlargement of certain portions of this tube and by foldings and thickenings of its walls the brain and spinal cord are formed (Figs. 12, 15, *C, D*). The retina or sensory portion of the eye is formed as an outgrowth from the fore part of the brain (Fig. 15, *D*); the sensory portion of the ear comes from a cup-shaped depression of the superficial ectoderm which covers the hinder portion of the head (Fig. 15, *E* and *F*). The back bone begins to appear as a delicate cellular rod (Fig. 12, *ch*), which then in higher vertebrates becomes surrounded successively by a fibrous, a cartilaginous, and a bony sheath. And so one might go on with a description of all the organs of the body,

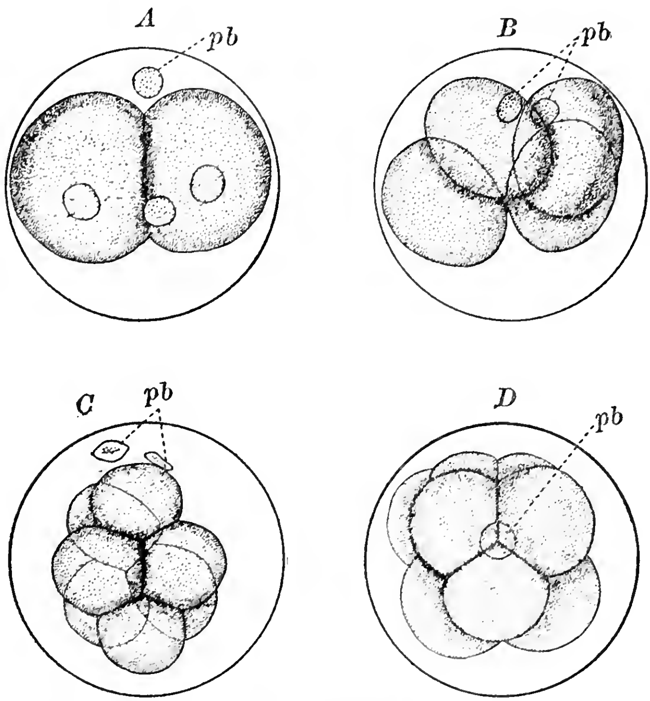


FIG. 13. FOUR CLEAVAGE STAGES OF THE SHEEP; *pb*, polar bodies. (After Assheton.)

each of which begins as a relatively simple group or layer of cells, which gradually become more complicated by a process of growth and differentiation, until these various embryonic organs assume more and more the mature form.

6. *Oviparity and Viviparity.*—This very brief and general statement of the manner of embryonic development applies to all vertebrates, man included. There are many special features of human development which are treated at length in works on embryology, but which need not detain us here since they do not affect the general principles of development already outlined. In one regard the development of the human being or of any mammal is apparently very different from that of a bird or frog or fish, viz., in the fact that in the former the embryonic development takes place within the body of the mother whereas in the latter the eggs are laid before or soon after fertilization. In man, after the cleavage of the egg, a hollow vesicle is formed, which becomes attached to the uterine walls by means of processes or villi which grow out from it (Fig. 14, *D, E, F*) while only a small portion of the vesicle becomes transformed into the embryo. There is thus established a connection between the

embryo and the uterine walls through which nutriment is absorbed by the embryo. And yet this difference is not a fundamental one for in different animals there are all stages of transition between these two modes of development. While in most fishes, amphibians and reptiles

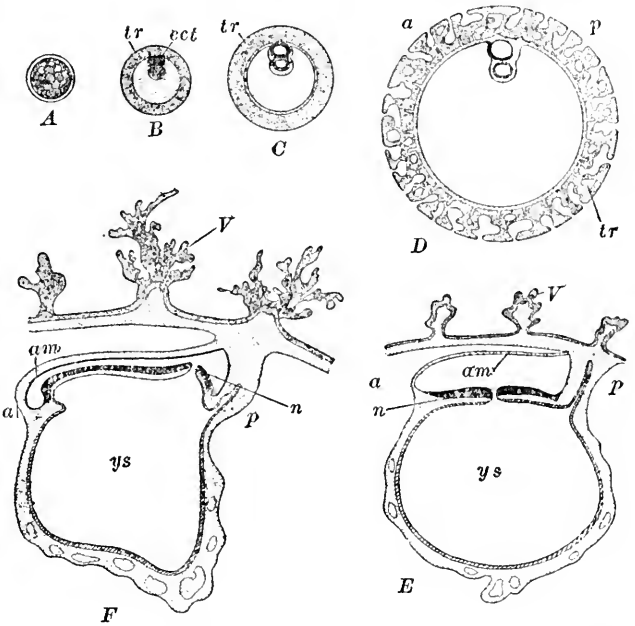


FIG. 14. DIAGRAMS SHOWING THE EARLY DEVELOPMENT OF THE HUMAN OOSPERM. *A*, cleavage stage which has just come into the uterus; *B* and *C*, blastodermic vesicles embedded in the mucous membrane of the uterus; *D*, *E* and *F*, longitudinal sections of later stages, the anterior and posterior poles being marked by the axis *a p*. In *C* cavities have appeared in the ectoderm, entoderm and mesoderm. *D*, villi forming from the trophoblast (nutritive layer, *tr*); black indicates ectoderm (*ect*); oblique lines, entoderm; few stiples, mesoderm; *V*, villi; *am*, amnion; *ys*, yolk sac; *n*, neurenteric canal (× 25). (From Keibel.)

the eggs are laid at the beginning of development and are free and independent during the whole course of ontogeny, there are certain species in each of these classes in which the development takes place within the body of the mother. Even in birds a portion of the development takes place within the body of the female before the eggs are laid, and there are mammals (monotremes, marsupials) in which the young are born in a very early and imperfect condition. These facts indicate that there is no fundamental difference between oviparity and viviparity. In the latter the union between the embryo and the mother is a nutritive but not a protoplasmic one. Blood plasma passes from one to the other by a process of soakage, and the only material influences which can affect the developing embryo are such as may be conveyed through the blood plasma and are chiefly nutritive in character. Careful studies have shown that supposed "maternal impressions" of the physical, mental, or emotional conditions of the mother upon the unborn child have no exist-

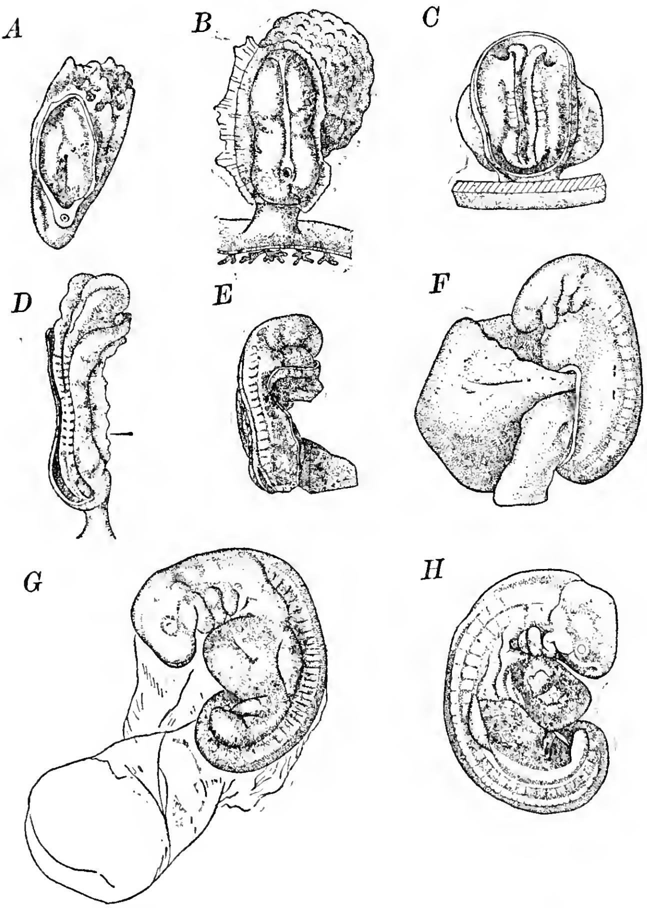


Fig. 15. *A–H*, successive stages in the early development of the human embryo. *A*, blastodermic vesicle showing primitive axis in embryonic area; age unknown. *B*, blastodermic vesicle attached to uterine wall at the posterior pole, showing neural groove; age unknown. *C*, later stage in which the neural folds are closing and five pairs of somites have appeared; age, ten to fourteen days. *D*, stage of fourteen somites showing enlargements of the neural folds at the anterior end which will form the brain; age, fourteen to sixteen days. *E* and *F* later stages, the latter with twenty-three somites and three visceral clefts. The ear shows as a depression at the dorsal angle of the second cleft. *G*, embryo of thirty-five somites showing eye, branchial arches and limb buds. *H*, embryo of thirty-six somites showing nasal pit, eye, branchial arches and clefts, limb buds and heart. (After Keibel.)

ence in fact, except in so far as the quality of the mother's blood may be changed and may affect the child. At no time, whether before or after birth, is the mother more than nurse to the child. Hereditary influences are transmitted only through the egg cell and the sperm cell and these influences are not affected by intra-uterine development. The principles of heredity and development are the same in oviparous and in viviparous animals—in fish, frogs, birds and men.

*Summary.*—This is a very brief and incomplete statement of some of the important stages or phases of the development of the body of man or of any other vertebrate. In all cases development begins with the fertilized egg which contains none of the structures of the developed animal, though it may exhibit the polarity and symmetry of the adult and may also contain specific kinds of protoplasm which will give rise to specific tissues or organs of the adult. From this egg cell arise by division many cells which differ from one another more and more as development proceeds, until finally the adult animal results. A specific type of development is due to a specific organization of the germ cells with which development begins, but the earlier differentiations of the egg are relatively few and simple as compared with the bewildering complexities of the adult, and the best way of understanding adult structures is to trace them back in development to their simpler beginnings and to study them in the process of becoming.

7. *Development of Functions.*—The development of functions goes hand in hand with the development of structures; indeed function and structure are merely different aspects of one and the same thing, namely organization. All the general functions of living things are present in

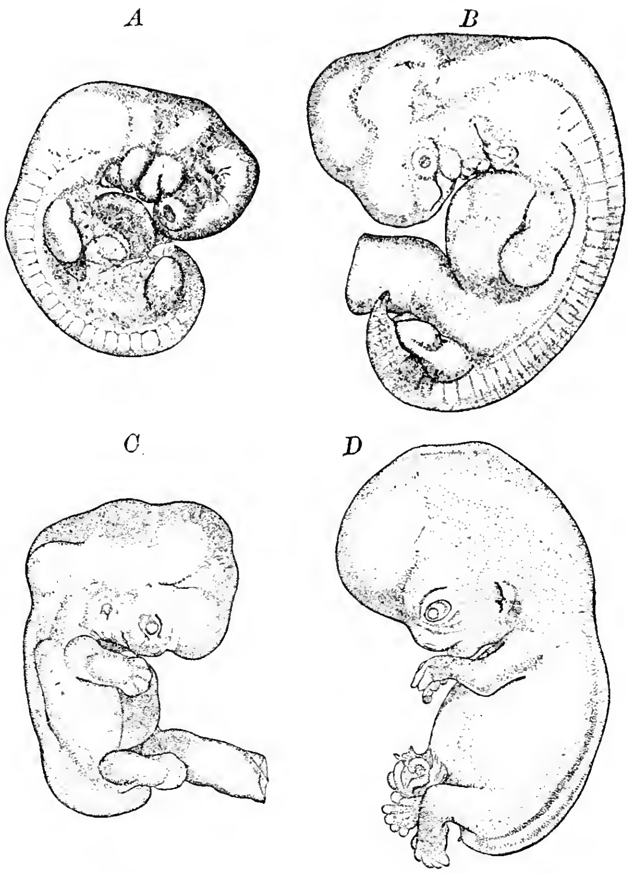


FIG. 16. *A*, human embryo of forty-two somites; ages about twenty-one days. *B*, embryo of about four weeks. *C*, still older embryo showing the beginnings of the formation of digits. *F*, embryo of about two months. (After Keibel.)

the germ cells, viz., (1) Constructive and destructive metabolism, (2) Reproduction, as shown in the division of cells and cell constituents, (3) Irritability, or the capacity of receiving and responding to stimuli. All these general functions of living things are manifested by germ cells, but as development advances each of these functions becomes more specialized, more complicated and more perfect. A cell which at an early stage was protective, locomotor and sensory in function may give rise to daughter cells in which these functions are distributed to different cells, cells which at an early stage were sensitive to many kinds of stimuli give rise to daughter cells which are especially sensitive to one particular kind of stimulus, such as vibration, light, or chemicals.

Functions develop from a generalized to a specialized condition by the process of "physiological division of labor" which accompanies morphological division of substance. But just as in the development of structures, new parts, which were not present in the germ, appear by a process of "creative synthesis," so new functions appear in the course of development, which are not merely sorted out of the general functions present at the beginning, but which are created by the interaction and synthesis of parts and functions previously present.

Much less attention has been paid to the development of functions than to the development of structures, and consequently it is not possible to describe the former with the same degree of detail as the latter. But in spite of the lack of detailed knowledge regarding the development of particular functions the general fact of such development is well established. To what extent structures may modify functions or functions structures, in the course of development, is a problem which has been much discussed, and upon the answer to which the fate of certain important theories, for example Lamarckism, depends; but this problem can be solved only by thorough-going experimental and analytical work. In the meantime it seems safe to conclude that living structures and functions are inseparable and that anything which modifies one of these must of necessity modify the other also; they are merely different aspects of organization, and are dealt with separately by the morphologists and physiologists only as a matter of convenience. At the same time there can be no doubt that minute changes of function can frequently be detected where no corresponding change of structure can be seen, but this shows only that physiological tests may be more delicate than morphological ones. In certain lines of modern biological work, such as bacteriology, cytology, genetics, many functional distinctions are recognizable between organisms which are morphologically indistinguishable. But this does not signify that functional changes precede structural ones, but only that the latter are more difficult to see than the former. For every change of function it is probable that an "unlimited microscopist" could discover a corresponding change of structure.

 (*To be concluded.*)

# THE STRUGGLE FOR EQUALITY IN THE UNITED STATES

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## VII

### The Current Trend of Affairs

No one in this generation has expressed the idealism of the American people as well as Mr. Roosevelt in his best moments. Speaking at Jamestown, Virginia, he said:

> The corner stone of the Republic lies in our treating each man on his worth as a man, paying no heed to his creed, his birthplace or his occupation, asking not whether he is rich or poor, whether he labors with head or hand; asking only whether he acts decently and honorably in the various relations of his life, whether he behaves well to his family, to his neighbors, to the state.

In the pursuit of this ideal, the present era of reform is beset with five difficulties. The first is the difficulty that arises from flattering the intelligence of the common man. A political order in which every man has one vote irrespective of his intelligence encourages the erroneous idea that one man knows as much as another, and makes the employment of the scientific expert appear to be a waste of the public money. Many a man who has clearly demonstrated his incapacity to manage his own affairs feels entirely competent to run the much more complicated affairs of the state and the nation.

> Nothing pleases the average mortal more than an assurance that his abilities would have qualified him to do something else much better. It gives him such a comfortable sense of completeness and versatility. Convince a curate that he would have made a capital buccaneer, and he will break most of the commandments for you. A man of science, persuaded that his first-rate abilities for the practical work of the world are wasted for lack of outlet, is as wax in the hands of the persuader.[1]

The second is the difficulty of distinguishing between reformers that are genuine and those that are fakes. According to scriptural writ, "Not every one that saith unto me, Lord, Lord, shall enter into the kingdom of heaven." Neither is every measure labeled "progressive" necessarily what it pretends to be. When some profess to be conservatives and others profess to be progressives, it is difficult enough to tell which is which, but when practically every one claims to be a reformer it is doubly difficult to draw the line between the quack nostrums of pretenders and well-meaning but unbalanced reformers, on the one hand,

[1] Hartley Withers, *op. cit.*, p. 66.

and on the other hand, the specifics of those who not only have the cause of society at heart but whose judgments are sure.

The third difficulty is the perplexing problem of determining just how far the self-interest of the individual is consistent with the general good. How much shall freedom of contract be abridged? How much social control shall be exerted over the individual in other directions? How far shall combinations of labor and capital be permitted to go in carrying out their purposes? Amid the complex conditions of modern life, these questions are more difficult to answer than ever before. It is all clear enough that restrictions here and there upon the liberty of the individual make for the greater liberty of the whole. Without some restrictions there would be nothing to arrest the hand of the social marauder. But then again individual initiative has been the great factor in human progress. Few things have done as much to advance mankind from the age of stone to the age of steel. If the individual is put in leading strings, our civilization may become stagnant. Not to push social restraint far enough is to invite anarchy. Selfishness is at once the thing that makes for progress and makes the attainment of perfection impossible. Just where is the point to curb it so as to secure the good without the evil that it works?

A fourth difficulty is the danger of insisting too little upon the fundamental principles of right conduct. Men do not do good because their hearts are evil is an old saying still worthy of belief. The primary need of every man is the reformation of his own life. It is well enough at times to protest against the wrongs inflicted upon one by others. No man worth the saving will consciously permit himself to be imposed upon or taken advantage of by others. But it is still more important that those who protest see to it that their own hearts conform to what is right and true and of good report. Those who demand justice should see to it that their own hands are clean. The first duty of organized labor is to keep itself free of such leaders as the McNamaras. The protesting spirit occasionally forgets the value of the heritage bequeathed to us by the past and the fact that there is more of good than of evil in the world. It at times runs dangerously near the point of revolt, as in some of the doctrines openly proclaimed by the militant branch of the Industrial Workers of the World. "I am come not to destroy, but to fulfil" are words which should not be forgotten. There is a crying need for more of the law-abiding spirit, for more men of high principle and of a staunch adherence to the right because it is the right.

A fifth difficulty is the tendency of the masterful element in human nature to run to extremes. The desire for domination is strong. The fighting instinct is covered with a thin veneer. An overbearing spirit is sometimes not far removed from the spirit of fair play. The craving for distinction within moderation is a wholesome desire, but snobbishness is thoroughly reprehensible. Ancestral pride is sometimes carried to this extreme. There is a proneness to regard foreigners as inferiors. Every community beyond the frontier stage has its social cliques. Shop-girls sometimes refuse to fraternize at dances with domestic servants. The work of the latter is commonly regarded as menial. The privilege of exclusiveness is one of the things paid for in Pullman cars. Social precedence is with some the main thing in life. Some rich heiresses make marriage with the titled nobility of Europe their chief ambition.

> No people ever displayed the passion for inequality more greedily than we. One builds a yacht, and if he can dine an English prince at the Cowes races, or entice the German Emperor on board at Kiel, this single breath of royal atmosphere at once endows the enterprising host with the rarest social privileges at home. Every circle breaks at the touch of the king's hand.[2]

The white man loves to lord it over the black man. In some states, many whites are exempt from the educational or property qualifications to which the negro is subject. The railway, hotel and educational facilities provided for the colored race are frequently greatly inferior to those provided for the white race. The person of negro descent is greatly circumscribed in his opportunity to earn a living. In Syracuse, Ohio, a negro is not permitted to stay over night. Some churches have been rent asunder over the question of admitting a negro to membership. It is with great difficulty that a negro can buy property in many communities. The average white man may contribute to save the soul of the black man in Africa, but he does not care to have a negro who is not his servant reside in the same block. This attitude is often as marked among the descendants of abolitionists as among any other class. To call a white person a negro in some states renders one liable to a suit for damages.[3]

## I

The present era of reform has made few serious mistakes in meeting the foregoing difficulties. It has reduced passenger fares and freight rates in some instances without due consideration. It has blundered more or less in trying to solve the trust problem. In many states it has not taken the first steps toward preventing the feeble-minded from polluting the race at its source. It has not addressed itself seriously enough to the solution of the race problem. "I will permit no man to injure me by making me hate him," Booker T. Washington once remarked. The present era has made little progress toward this lofty ideal. Perhaps the most ominous mistake has been the increasing expenditures for militarism including pensions. The competitive building of armaments has become a crying evil.

2 John Graham Brooks, "The Social Unrest," p. 235.

3 Gilbert Thomas Stephenson, "Race Distinctions in American Law," *passim;* Frank U. Quillan, "The Color Line in Ohio," *passim.*

In the main, however, the course of events has been so moderate as to attract and not to repel adherents. There is no evidence that the country is growing less radical, or that it is tiring of reform. Probably there has been no decade in the country's history during which humanitarian measures have scored so many victories as during the last ten years. Hypocrisy has been mercilessly unmasked. One stronghold of privilege after another has been assaulted. Conduct once supposed to concern no one but the individual has been seen to have a public aspect, and some of the points at which the self-interest of the individual is inconsistent with the public welfare have been noted and a measure of collective control has been imposed. The public has become more exacting in the demands which it makes upon its servants. There is a quickening influence felt in nearly every direction. The man absorbed in business and the closet philosopher are waking up to the claims of public affairs, and are contesting the supremacy of those who have hitherto run our politics. There is a growing realization that we have had the forms without the substance of a real democracy. It is not so much statutory enactments as the general atmosphere of criticism in which the ordinary man lives and works that is making for higher standards of private and public conduct. The discriminating character of the times nowhere appears to better advantage than in the readiness with which sham reformers and their works are detected and rejected. Most men are progressive in spots and the public is showing the good sense necessary to distinguish between the respects in which those who profess to lead it face the future and those respects in which they face the past. The subsidized press has lost much of its influence. It is the critical attitude of the age that is so full of promise for the future.

A notable change in public opinion has taken place since 1896. At that time the man successful in gaining public office stood primarily for an ultra-individualism and for upholding property rights. The prevailing view was that a man acted in consonance with the public interest in securing the kind of a tariff or franchise that he wanted. This idea is to-day discredited. The emphasis has shifted somewhat from business success to the broader interests of mankind. Society has become less complacent with unwholesome conditions. It is more generally understood that sweat-shops, unsanitary tenements and unduly long hours of labor threaten the well-being of the public at large as well as that of the victims immediately involved. An awakened people is striving to control its political institutions. Moreover, business and politics are such close bed-fellows that the improvement in the latter reflects the change for the better that has taken place in the former.

The forward movement of recent years has not won its triumphs without a fight. Nearly every inch of the ground has been contested by skilled and often opulent adversaries. The vested interests affected have opposed the spirit of progress for the same reason that the silversmiths dependent upon the votaries of Diana for their living and prosperity arrayed themselves against the preaching of Paul. Nor is this surprising. Those whose pockets are threatened by any proposed reform naturally try to get off with as little loss as possible. In addition to the opposition offered by vested interests, that due to the inertia of society and to impracticable reformers has had to be met and overcome. The indifference of many of the intelligent and respectable is one of the greatest barriers to progress. The obstacles that have been successfully encountered and overcome inspire the hope that the spirit of the age is moving in the right direction.

The world-wide character of the present era of discontent strengthens and confirms this hope. In England, Germany, France and other nations there is a forward movement that has much in common. In many of the more backward countries, the suffrage is being broadened and the people are playing a more influential part in governmental affairs. The fact that personal liberty calls for more interference on the part of the state is quite generally recognized. It is not the old-time marauder who waylays his victim with a club against whom protection is needed so much as the superior cunning and unscrupulousness of a certain type of the modern man of affairs. In every progressive country, the community is now doing things which the common man once attended to himself. The individual is becoming more dependent upon the state to safeguard him against monopoly, foul air, impure milk, adulterated food and unsanitary plumbing, and to insure him against the contingencies of sickness, unemployment, accident and old age. The duty of protecting the individual against unduly long hours of labor and unwholesome conditions while at work, of preserving him from improper amusements in his leisure moments, and of supplying him with the educational facilities necessary to start him properly in life and to meet his mental and esthetic needs in his mature years is devolving more and more upon the state. There is a concerted movement to give the man who has been worsted in life a chance to get upon his feet and regain his self-respect. The growing density of population and its concentration in cities are socializing the production of certain things with which the individual has commonly supplied himself. Many European cities have municipalized the supply of water, light and local transportation. The Cincinnati board of health took over the ice plants of the city during the strike last summer. The federal government has established postal savings banks and a parcels-post, and government ownership and operation of the telephone, telegraph and railway are spreading throughout the world.

Another evidence that the present trend of affairs is not far amiss is that men seldom break things as they are without just cause. The power of custom and tradition is strong. The religion or politics of most men is a birthright. The keen joy which the partisan of any cause experiences comes partly from being one of a multitude. The average man feels a sense of loss without a political party. There is an element in human nature which craves authority. Obedience is easier than disobedience. Many men instinctively crave direction. One function of dogma is to relieve people from the disagreeable necessity of doing their own thinking. The *raison d'être* of the political boss lies partly in relieving the community from a lot of trouble. The extraordinary longevity of the Roman Catholic Church indicates that it ministers to something fundamental in human nature. As James Bryce says:

> Most men are fitter to make part of the multitude than to strive against it. Obedience is to most sweeter than independence; the Roman Catholic Church inspires in its children a stronger affection than any form of Protestantism, for she takes their souls in charge, and assures them that, with obedience, all will be well.[4]

## II

At first blush, the difficulty of solving the problems of the day seems a good argument against popular government. But second thought points to just the reverse conclusion. The frequency with which men vote according to their interests rather than according to reason makes it well to give the mass of men a voice in affairs to protect them from oppression. What state or section would be willing to entrust its interests to the remainder of the country? Likewise, what reason is there to suppose that the interests of any class will receive as much consideration if it is disfranchised as if it has the ballot? Would the Irish or the Scandinavian elements in our population receive as much political recognition if they did not have votes? Now that women vote in a number of states, there is some chance that an amendment to the federal constitution granting the ballot to women will be submitted to the legislatures of the several states. The disfranchisement of the negro in certain states has been followed by a movement to segregate the school funds. But altogether aside from this, the judgment of the untutored mind is often worth taking into account in solving social problems. When one considers the sophistry with which many men of reputed intelligence habitually deceive themselves and others upon the tariff, one feels encouraged to appeal to the good sense of the common man. The results frequently justify the appeal. What class is so well qualified by experience to know the evils of ill-ventilated workshops, dangerous machinery and unsanitary tenements as the working class? The associations of the professional man, the merchant or the large manufacturer tend to produce a class spirit that precludes any great familiarity with the common lot. The initiative for much of the legislation that has

[4] *Op. cit.*, Vol. II., p. 355.

lightened the burdens of those who toil has been supplied by organized labor. "I see no reason why the rule of the majority should be the rule of ignorance, unless they are not only ignorant but fools," remarks Professor Cooley.[5]

The sentiments of justice, liberty, truth and patriotism are especially strong among the masses. The spirit of brotherhood manifested in acts of kindness and service to those in need is more prevalent among the poor than among the rich. It was the common people in New England who carried through the Revolution. The men of wealth and standing were largely against it.[6] The Tories everywhere consisted chiefly of men of property. The masses in England "upheld abolition in the colonies and sympathized with the North in the American Struggle."[7] If we are to have a narrow suffrage, to what portion of society shall it be restricted? Shall we entrust our currency solely to the bankers or the political economists? There is no class whose mental horizon and sympathies are broad enough to control the destinies of the state. In the opinion of Thomas Wentworth Higginson, there has never been a period since the American people gained their independence when control of the nation by its highly educated men alone would not have been a calamity.[8] So unfriendly a critic of democracy as Lecky remarks:

> It has been the opinion of some of the ablest and most successful politicians of our time that, by adopting a very low suffrage, it would be possible to penetrate below the region where crochets and experiments and crude Utopias and habitual restlessness prevail, and to reach the strong, settled habits, the enduring tendencies, the deep conservative instincts of the nation.[9]

Universal suffrage in practise has worked much better than many of its opponents have predicted. The dire predictions of Macaulay in 1857 are a striking example.[10] Our "fertile and unoccupied land" is practically gone. Parts of New England are "as thickly peopled as old England." We have our "Manchesters and Birminghams." Periods of economic distress have come and gone. At times a multitude of people "has not had more than half a breakfast" or expected "more than half a dinner," but the poor have not plundered the rich, nor has civilization been saved at the price of liberty. The demagogue has asked "why anybody should be permitted to drink Champagne and to ride in a carriage, while thousands of honest folks are in want of necessaries," and yet we have not been ravished by the Huns and Vandals engendered

5 Charles Horton Cooley, "Social Organization," p. 145.

6 Thomas Wentworth Higginson, "The Cowardice of Culture," *Atlantic Monthly*, Vol. 96, 1905, p. 483.

7 Cooley, *op. cit.*, p. 136.

8 *Op. cit.*, p. 483.

9 *Op. cit.*, Vol. I., p. 293.

10 George Otto Trevelyan, "The Life and Letters of Lord Macaulay," Vol. I., pp. 451–454.

within us. No Cæsar or Napoleon has seized "the reins of government with a strong hand."

A wide suffrage is a mental stimulus to the whole community. By abolishing everything that smacks of caste in voting, it arouses in the common man a desire to better his social and economic condition. It promotes an interest in public affairs. It helps the newspapers to keep the public mentally receptive. It fosters a system of education at public expense which begins at the kindergarten and ends with the university. It makes for the amelioration of social conditions. It discourages the growth of an educated aristocracy. It puts the more enlightened under the necessity of persuading the less enlightened to its way of thinking, a work that is no less helpful to the former than to the latter. It helps to widen the circle of readers and stimulates the popularization of knowledge. The market for the numerous books and periodicals that are published to-day depends in part upon universal suffrage. The rule of the people does not necessarily mean government by either the most ignorant or the most enlightened, but it raises the general level of intelligence.[11]

The right to vote has a sobering effect. It arouses a sense of responsibility. It develops self-respect. It makes for patriotism. It gives the foreign-born a sense of oneness with ourselves. It deprives violent men of any valid excuse for violence. It gives zest to freedom of discussion. The right to talk relieves the feelings of the man who talks. The right to vote offers a remedy for all grievances real and imaginary. Neither the reckless utterances of the strike leader nor those of the politician should be taken too literally. The responsibility of office usually sobers the latter, and the former, if placed on the police force, often proves a staunch defender of law and order.

A democratic suffrage is manifestly not suited to every stage of civilization. The wholesale enfranchisement of the negro by the fifteenth amendment was probably a mistake. It is notorious that many of the Latin-American peoples have never achieved anything more than a paper democracy. It is said that Venezuela has averaged one revolution a year during the last thirty years and that one is now six months overdue. Such highly unstable societies exemplify not the rule of the many, but the tyranny of the few. It is as patent, however, that we have progressed beyond the kindergarten stage in democracy as that certain other peoples have not yet reached that stage.

Probably there is no better evidence of this than that supplied by the state of Wisconsin. In freeing themselves from the humiliation of corporate rule, in subjecting the railways of the state to public control, in regulating the public service corporations, in distributing the burden of taxation more equitably, in electoral reform, in articulating the state

11 Charles W. Eliot, "American Contributions to Civilization," pp. 21–30.

university with the administration of public affairs, and in bringing the services of experts to the aid of the state, the people of Wisconsin have manifested excellent self-control and have conclusively demonstrated their capacity for self-government. The steady growth in popular favor of the state universities of the entire central west is a most reassuring fact. Dependent upon taxation for support and administered by boards elected directly by the people, they have successively raised their standards of admission, greatly increased their enrollments, developed graduate and professional schools, and toned up the secondary schools. In their standards of scholarship, several of them have become the rivals of the older institutions that rest upon private foundations in the east. There has been uncertainty at times, but the open discussion by which these institutions have won their way gives them a most promising future. To what more exacting test could democracy be subjected?

A wide suffrage does not do away with the need of leadership. Only the exceptional man can express the feelings and thoughts of the multitude. Because one man counts as much as another at the ballot box, it does not follow that this is true in the formation of public opinion. There are individuals who contribute in a conspicuous way to the process. The contributions of the masses, while enormous in the aggregate, are small per man.

> One mind in the right, whether on statesmanship, science, morals, or what not, may raise all other minds to its own point of view—because of the general capacity for recognition and deference—just as through our aptitude for sudden rage or fear one mind in the wrong may debase all the rest.[12]

On the other hand, the scrutinizing eye of the multitude lifts the plane of leadership to a higher level. In the words of Ex-President Eliot:

> . . . the collective judgment is informed and guided by the keener wits and stronger wills, and the collective wisdom is higher and surer in guiding public conduct than that of one mind or of several superior minds uninstructed by million-eyed observation and million-tongued debate.[13]

A new type of political leader is coming to the front, one who knows how to address himself directly to the people. The opportunity for the man who does all his work behind the closed doors of a committee room is passing. The call is for men who not only have constructive minds, but who, in addition, have the capacity for leadership and effective utterance on the stump. We are consequently witnessing a revival of public speaking. Never before have good health and a good presence been so indispensable in public life. The change that is taking place is not wholly for the better. As a result, a certain kind of quiet, unobtrusive man may be lost to the public service. Tenure of office for a

[12] Cooley, *op. cit.*, pp. 124–125.
[13] *Op. cit.*, p. 77.

time at least may be more unstable. But the prospect is that what is gained will more than compensate for what is lost. The new type of leader promises to be more stimulating, more informing, more given to discussing questions of justice, and beyond doubt more responsive to the progressive thought of the time. The man who calls other public men to account by reading their votes on the questions of the day is a valuable addition to the public service.

Popular rule may not always command the services of the most efficient men. It may content itself with mediocrity. It may even on occasion elect a crook to office, but, if so, it will not be because he is a crook. Moreover, the crook who owes his position to the people may not act like a crook at all. The people will condone many an error of judgment so long as they believe in a man's honesty. In judging our public men, it is only fair that due allowance should be made for the stinging criticism to which they are exposed. Their motives are all the time called in question, every mistake or weakness is duly noted. If men in the private walks of life were subjected to the same ordeal, many of them would not shine by comparison. Our railway and trust magnates do not always successfully withstand the searching light of criticism.

Some writers who question the wisdom of the referendum admit that the masses are shrewd judges of men. The men elected to public office correspond roughly to what the positions require. Our county and municipal offices are usually filled by rather ordinary men. The governors of the several states represent a better grade of ability. The presidency commands men of a very high order. When it comes to filling important positions, the voters usually display a good deal of sense. As our cities have grown in size and the problem of governing them has become more difficult, more capable men have been elected to municipal offices. This explains the spread of commission government. The general adoption of the short ballot would do away with the needless number of elective offices, concentrate responsibility and help to keep not only the crook, but the mediocre man out of public office. There is no weapon so deadly to dishonesty or incompetency in either public or private life as the certainty of exposure.

The fact that the people do not more frequently prefer college-bred men as their political leaders sometimes occasions regret. But the fact is not necessarily the fault of democracy. It is largely due to the newness of our environment. Life on the frontier encourages contempt for experience, lack of respect for training, a profound faith in natural qualities, and an inordinate respect for the opinions of "self-made men." It rarely suggests the need of the college-trained mind. The failure of college-trained men to gain political recognition is also due occasionally to lack of force and an assumed superiority. The man of books is often disqualified for a life of action. The gradual extension of the merit system and the growing number of experts employed in the conduct of governmental affairs indicate that democracy is not necessarily inconsistent with efficiency in the public service. In any event, an influential portion of the property-owning class is no less responsible than the working class for the manifest failures in our municipal, county, state and federal governments. The mistake of supposing that some new kind of political machinery, such as commission government, will work desirable results without the watchful eye of an intelligent electorate is not confined to any one class.

It does not follow that the services of a man who is not elevated to an elective office are lost to the country. The case of Mr. Bryan, whom an error of judgment on the silver question and the "cross of gold" speech brought into prominence, is a good illustration. He has never reached the presidency, but as the critic of his own as well as of other parties he has rendered the country more distinguished service than some who have reached the highest office in the gift of the people. Many of the positions of greatest influence are outside of public office. There is no occasion to despair of the influence of the educated man who can think and express himself clearly.

> We may rail at "mere talk" as much as we please, but the probability is that the affairs of nations and of men will be more and more regulated by talk. . . . there can be no doubt that it is talk—somebody's, anybody's, everybody's talk . . . by which each generation comes to feel and think differently from its predecessor. No one ever talks freely about anything without contributing something, let it be ever so little, to the unseen forces which carry the race on to its final destiny. Even if he does not make a positive impression, he counteracts or modifies some other impression, or sets in some train of ideas in some one else, which helps to change the face of the world.[14]

The late Edwin L. Godkin justly complained of the influence of the boss in our nominating system, of the decline of our state legislatures, of the prevalence of the spoils system, of the lack of public spirit, and of our failures in municipal government.[15] These evils are still with us, but the changes that have taken place, while leaving much to be desired, have been, for the most part, in the right direction. In no respect has there been greater improvement than in the weakening of party ties and the growing influence of the independent voter. An excessive loyalty to party was one of the unfortunate results of the Civil War. In the South, voting the democratic ticket became almost a *sine qua non* for admission to polite society. In many northern communities, the republican party

> was merely a synonym for patriotism, another name for the nation. One became, in Urbana and in Ohio for many years, a Republican just as the Eskimo dons

[14] Edwin L. Godkin, "Problems in Modern Democracy," pp. 221, 223 and 224.

[15] See "Unforeseen Tendencies of Democracy," *passim.*

fur clothes. It was inconceivable that any self-respecting person should be a Democrat. There were, perhaps, Democrats in Lighttown; but then there were rebels in Alabama, and in the Kuklux Klan, about which we read in the evening, in the Cincinnati *Gazette*.[16]

Party loyalty within reason serves a useful purpose. It gives stability to public policy. It holds the party together for future contests. It may mean devotion to principle, if the party stands for some great cause. None-the-less, a blind devotion to party has been the bane of our politics. It has introduced the extraneous issues of national politics into our state and municipal contests. It has kept the unprincipled leader in power. It has countenanced alliances between political machines subservient to the same sinister influences. It has acted as the catspaw of the interests which participate in politics for private gain, the most consistent of non-partisans. The growing independence of the electorate is consequently a hopeful symptom. The greenback and populist movements helped to break the crust of habit in voting, whatever one may think of some of the vagaries for which they stood. The gold democrats in 1896 helped to save the country from free silver, and the independent democrats in New York City, Baltimore and Maryland have repeatedly saved the cause of good government by breaking with their party. The independent republicans in Cincinnati, Cleveland and Philadelphia have done a similar work. The independents in all parties in Toledo and Chicago have greatly improved the tone of municipal government. The results of the referenda in Ohio, Oregon and other states show a disposition on the part of the voters to discriminate. Party organizations give coherency to political action, but the influence of the independent voter is necessary to keep them within bounds.

The increase of the Socialist vote is exerting a wholesome influence, however much one may dissent from some of the cardinal points for which the party stands. It forces people to reexamine the foundations of their political faiths. It obliges the leaders of other parties to revise their platforms. It gives large numbers for the first time in their lives a political cause worthy of their devotion. Some news-dealers like to sell *The New York Call* for the sake of the cause which it represents. Many corner and bar-room loafers, now that they have become Socialists, are no longer purchasable on election day. A man who handled large sums of Senator Stevenson's money in Wisconsin testified that no money was used in the strong Socialist wards of Milwaukee.

The moral is clear. The remedy for our political ills lies in quickening the general intelligence and in appealing to the idealism latent in the people rather than in a narrow suffrage. The latter will not save

[16] Brand Whitlock, "Forty Years Of It," *The American Magazine*, January, 1913, p. 18.

us from the danger of corruption. A century or more ago, the suffrage was anything but democratic and yet there was scarcely any kind of political chicanery which the men then in public life did not practise. "In filibustering and gerrymandering," writes Professor McMaster, "in stealing governorships and legislatures, in using force at the polls, in colonizing and in distributing patronage to whom patronage is due, in all the frauds and tricks that go to make up the worst form of practical politics, the men who founded our State and national governments were always our equals, and often our masters."

While no one can be blind to the evils which have been associated with democracy in the United States and in the Old World, no serious student of history, when he compares the long train of abuses, brutalities and disorders connected with the rule of kings, priests and nobles, can doubt for an instant that as between democracy and the outworn systems of the past there can be no choice. Every branch of law that has been recast under the influence of popular will has been touched with enlightenment and humanity. Compare the brutal criminal codes of old Europe with the still imperfect but relatively enlightened codes of our own time. Compare the treatment of prisoners, women and children, the education of the youth, and the public institutions devoted to general welfare, with those existing before the age of democracy. Mr. Bryce's remark that evidences of philanthropy and humanitarianism are mingled in our state politics with folly and jobbery "like threads of gold and silver woven across a warp of dirty sacking" is true, and yet when one looks for evidences of philanthropy and humanitarianism in the folly and jobbery that characterized aristocratic and monarchical institutions in the old régime, one does not even have the satisfaction of getting the gleam of gold and silver across the dirty sacking.[17]

[17] Charles A. Beard and Birl E. Schultz, *op. cit.*, p. 14.

(*To be concluded*)

# THE FUTURE OF THE CHESTNUT TREE IN NORTH AMERICA

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NOW-A-DAYS one often hears the question, "What is going to become of our chestnut trees?" In fact, whenever the subject of trees is broached in the course of a conversation, this inquiry is bound to come out—not, as I believe, that the interrogator hopes to receive a satisfactory answer, but more in the way of a general query.

As I do not claim to be gifted with second sight, I do not mean to imply by the title of this paper that I can foretell the future of this tree—rather, in the same philosophical spirit of the interrogator, on the basis of certain facts relating to the past and present history of the species, I shall make an inquiry into its probable future.

It is natural that the condition of this tree should arouse concern, valuable as it is to us in a great variety of ways. For one thing, we are always in need of woods which, like the chestnut, are comparatively resistant to decay when in contact with the soil; and this is one of the main reasons why a large proportion of the railroad ties and telegraph poles in the eastern United States are of chestnut. However, as far as the finer, technical uses are concerned, such as interior finish of houses, furniture, etc., it is a decidedly second-class material because of its warping and checking tendencies; yet it is often used for these purposes, where the element of cheapness is the chief consideration. By the uninitiated, chestnut used in interior house finish may easily be mistaken for the more expensive ash. One of the chief sources of tannic acid, important in leather manufacture, is our chestnut tree. And every small boy, not to mention his elders, knows the value of the nuts, which are sweeter than those of its near relative, the European chestnut.

In addition to these valuable properties, when it grows in the open, the tree develops a massive, round head, with short, powerful trunk, and low-sweeping limbs, which make it a most beautiful ornamental tree (Fig. 2).

The natural range of the chestnut (*Castanea dentata*), is from southern Maine[1] to the valley of the Winooski River in northern Vermont, to southern Ontario, and along the shores of Lake Ontario[2] to southeastern

[1] Knight, Ora W., "Some Noteworthy Plants of the Penobscot Valley," *Rhodora*, 8: 65–66, 1906.

[2] Sargent, C. S., "Silva of North America," 9: 14, 1896.

Michigan,[3] southward in the eastern part of its range to Delaware, and in the west to southeastern Indiana[2] and extreme southern Illinois,[4] while it extends along the southern Appalachians to north central Georgia,[5] central Alabama[6] and Mississippi, and central Tennessee. This distribution is most easily remembered if we observe that it takes the general form of an ellipse, which is about twice as long as broad, with the southern end in central Mississippi, Alabama and Georgia, the northern end in Maine, New Hampshire and Vermont, while the greatest cross diameter of the ellipse extends from southeastern Michigan to Delaware (Fig. 1).

Although this is the area which now includes all chestnut growing naturally or "wild" in the United States, it does not necessarily represent the territory it has always occupied in the past. For geological evidence, as well as our own observational powers, show us that in both plant and animal worlds the confines of a species are constantly varying —now expanding, now contracting. This condition is evidently due to a great variety of factors, but at the very groundwork of them all lie the fundamental principles of the struggle for existence and the survival of the fittest. In modern times the modifying action of man on this perpetual contraction or expansion of a species has been by no means slight, and with the ever-increasing facilities of commerce, his influence is becoming more and more marked. To cite an example from the plant world, some of the most obnoxious weeds that grow about us to-day, and are the bane of the farmer, are intruders from foreign countries, their seeds having been brought in with various imported materials. Having thus arrived here, many of them find congenial soil and make their home among us, thereby considerably widening the range of distribution of their particular species. On the other hand, by the unwitting introduction of various fungous or insect parasites, man may be instrumental in the contraction or even the extinction of some of our plant or animal species.

Such examples as the bison, or the North American Indian, demonstrate how rapidly the distribution of a species or race may change, even within the memory of man.

Geological data, as furnished us in the form of fossils, are often illuminating as to the former distribution of our plant and animal species. For example, the giant big-tree and redwood, of California, quite prob-

3 Otis, C. H., and Burns. G. P., "Michigan Trees, a Handbook of the Native and Most Important Introduced Species," p. 95, Ann Arbor, 1913.

4 Gleason, H. A., "Additional Notes on Southern Illinois Plants," *Torreya*, 4: 168, 1904.

5 Harper, R. M., "Flora of Middle Georgia," *Bull. Torrey Bot. Club*, 27: 333, 1900. "Botanical Explorations in Georgia During the Summer of 1901," *ibid.*, 30: 294: 1903.

6 Mohr, Charles, "Plant Life of Alabama," Contributions from the U. S. Nat. Herbarium, 6: 60, 1901.

ably had formerly a much wider range than their present contracted limits, for fossils of conifers belonging to the same genus have been found even as far north as Greenland. And it is reasonable to assume that, if conditions remain the same, such species will continue to weaken and die out, although in this case also man's treatment can considerably modify the result.

Unfortunately, in the case of the American chestnut, there is no fossil evidence of its former distribution. Mr. F. H. Knowlton, of the United States Geological Survey, writes us: "So far as I know, the American chestnut has not been found fossil anywhere in this country, but the parent form, that of *Castanea sativa* (the European chestnut)

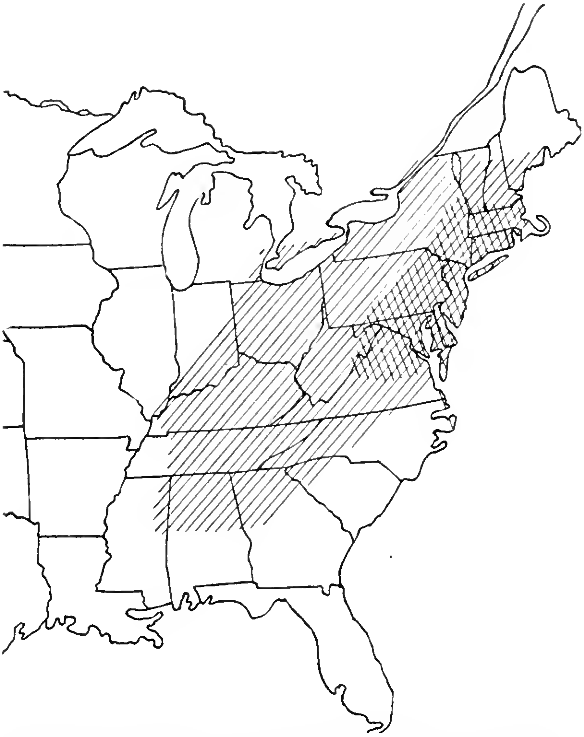

FIG. 1. SHOWING THE NATURAL RANGE OF THE AMERICAN CHESTNUT. The cross hatching shows in a general way the extent of territory covered by the chestnut bark disease.

has been found at a number of localities in England and Italy, in deposits of inter-glacial or pleistocene age." As far as the genus is concerned, *Castanea* once had a much wider range in North America than at present, for, according to Sargent,[7] "Before the middle tertiary period *Castanea* existed in northern Greenland, and in Alaska, where traces of the leaves and fruit of *Castanea Ungeri* Heer have been distinguished;

[7] Sargent, C. S., *loc. cit.*, p. 10.

and impressions of one and perhaps two species found in the miocene rocks of Oregon, and in those of the upper miocene of the Colorado parks, show that *Castanea*, which already existed in Europe in the cretaceous period, once inhabited western North America, whence it has now disappeared."

Coming now to the condition of the chestnut tree to-day, let us first figure up its liabilities, *i. e.*, those diseases and injuries from which it is prone to suffer, and then set down on the other side of the balance sheet its assets, *i. e.*, those inherent qualities which accrue to its advantage in the struggle for existence.

It is a significant fact that both the European and the American chestnuts have been attacked in recent years by serious diseases which have attracted a great deal of attention here and abroad. In Europe the disease known as the *Male dell' Inchiostro* and various other troubles have very seriously affected the European chestnut.

In the United States, the well-known bark disease, discovered in 1904 near New York City, has already caused enormous damage to the chestnuts in southern New England, New York, New Jersey, Pennsylvania, Delaware and Maryland, and it also occurs in Virginia and West Virginia[8] (Fig. 1). It is unnecessary here to describe this trouble in detail, as excellent accounts of it have already been published and are easily available.[9] It is sufficient to state that it is caused by a fungus which grows in the living bark of the tree, gaining an entrance through wounds or openings of any sort in the bark. As the fungus grows, it kills the bark, and by gradually increasing the radius of its operations, eventually reaches around the trunk or branch which it entered, in this way girdling it.

When this disease was first discovered, and its disastrous nature realized, one of the first questions that arose was that of the source of the causal fungus. Where did this fungus come from? Was it a native fungus, or was it brought into this country from abroad? It was easily seen that the answer to this question was of fundamental importance, for if the fungus was a native species, then its sudden attack was evidently due to unusual environmental factors of some sort, and with the recurrence of the normal conditions the virulence of the attack would cease. On the other hand, if the fungus were an imported parasite, there would be no telling where its depredations would end.

Those who held to the first theory, *i. e.*, that the fungus was a native

8 The disease has also been recently reported in a nursery in North Carolina. See Metcalf, Haven, "The Chestnut Bark Disease," *Jour. of Heredity*, 5: 8–18, 1914.

9 Metcalf, Haven and Collins, J. Franklin, "The Control of the Chestnut Bark Disease." U. S. Dept. of Agr., Farmer's Bull., 467: 1–24, 1911.

Clinton, G. P., "Chestnut Bark Disease," Rept. of Conn. Agr. Expt. Sta., 1912, 359–453; pls. 21–28, 1913.

form, believed that it had hitherto escaped the notice of botanists, occurring in an inconspicuous way as a weak parasite or saprophyte, but that conditions unfavorable to the chestnut, such as extremely cold winters and severe droughts, continued coppicing, etc., had rendered the tree susceptible to attack. As to the suddenness of the outbreak, this was to be accounted for by the very unusual climatic conditions which prevailed about the time of its appearance. Moreover, serious troubles of the chestnut had been before noted in this country, but had never been really explained.

On the other hand, those who believed the fungus to be an introduced species pointed to its apparent spread from the region around New York City as a center, our greatest port of entry, to the suddenness of the attack, to the fact that the fungus had never been observed here before, and lastly, to the partial immunity of certain varieties of the Japanese chestnut, which were first raised extensively on Long Island, the implication here being that the fungus might be a Japanese species to which, in their native home, the Japanese chestnuts had in the course of a long period of time become partially immune.

The last point was significant, but not conclusive, since the fungus had never been found in Japan, nor was it possible at the time to locate it in any foreign country.

In the course of time investigations brought out the fact that the fungus was closely related to a species already known in Europe and America, and by some was considered a variety of this, while others regarded it as a distinct species. Without going into details, it is sufficient to note the main fact emerging from them, namely, that the fungus was a new form, at least one not before known in Europe or America.

For a long time efforts to locate the fungus in the orient were without avail, but recently Mr. Frank N. Meyer, of the United States Department of Agriculture, has sent to Washington specimens from a blighted chestnut in China, which have been found to contain the identical fungus which has caused the trouble here. Moreover, from the nature of the locality in which it was collected, the fungus appeared to be indigenous. It should also be noted that the Chinese trees gave the appearance of being much more resistant to the disease than the American.[10]

Unless, indeed, we construct a theory of independent origin of species identically the same, due to essentially similar conditions of environment, we are justified, then, in believing that this parasite was brought into this country, and, judging from the past, may continue its steady

[10] Shear, C. L., and Stevens, N. E., "The Chestnut Blight Parasite (*Endothia parasitica*) from China," *Science*, N. S., 38: 295–297, 1913.

Metcalf, Haven, "The Chestnut Bark Disease," *Jour. of Heredity*, 5: 8, 1914.

advance in the area in which the chestnut naturally occurs. However, we shall consider this point again later.

In common with other forest trees, the chestnut is subject to the attack of several species of fungi which bring about a decay of the heart wood. Normally, the tree is protected from such invaders by its incasement of bark, but when this is injured in any way, a vulnerable spot is opened up through which fungi can enter. Notably is this the case in trees injured by forest fires, for here the living bark as well as the sapwood underneath may be entirely killed in spots, causing the so-called fire-scars, and furnishing an easy ingress for fungi. Once inside, in the heartwood, the fungus may work up and down in the interior of the trunk, softening the wood by its decaying action, or "dozing" it, as the lumbermen say. If the tree, thus deprived of the firmness of its solid cylinder of heartwood, its chief mechanical support, does not fall a prey to the next violent windstorm, it is in any case weakened, and the way lies open for attack upon its last stronghold, the sapwood and living bark.

Another widespread trouble of the chestnut, which I have found of common occurrence in New England forests, but apparently more destructive in the southern Appalachian mountains, is caused by the attack of the two-lined chestnut borer, *Agrilus bilineatus*. Next to the fungus which causes the bark disease, this insect is perhaps its most serious enemy. It is said to have a preference for trees enfeebled in some way, through such causes as drought, unfavorable soil conditions, etc., yet it is possible that where it breeds in great numbers it may be forced to attack vigorous individuals. In any case I have seen many examples of trees, which to all appearances had been in a perfectly sound condition, being rapidly killed by the attacks of this tiny grub. On opening up the inner bark, the long, sinuous channels of the larvæ were disclosed, now and then with a sharp turn in a lateral direction, the combined effects of several of these galleries resulting in a practical girdling of the tree. Many other insects attack the chestnut, but they are of secondary importance.

Let us next consider the practise of "coppicing." As is the case with many other of our forest trees, the chestnut habitually sends up sprouts from the stumps of felled trees, sometimes more than one hundred of these developing from a single parent stump. These "coppice" shoots grow rapidly, having the well-developed roots of the parent tree at their disposal for the absorption of nourishment from the soil, and enter into fierce competition with one another for light and space. Although in the natural course of events the weaker ones succumb and die out in the struggle, the woodsman may assist nature in this process of elimination by cutting out the weaker shoots early, in order to give the more vigorous ones a better chance In either case, eventually four or five, or rarely more, vigorous trunks remain, which on reaching a suitable size are cut down and used for railroad ties, telegraph poles, or lumber, as desired; and from their stumps new coppice shoots arise, to repeat the whole history of their forebears. In some regions this coppicing has gone on for four or five generations of sprouts.

The question now before us is, "Does this continued coppicing weaken the vitality of the chestnut tree and thus make it more susceptible to disease?" The general opinion seems to be in the affirmative. Zon,[11] speaking of the chestnut in southern Maryland says:

> It must not be forgotten, however, that a chestnut stump can not go on coppicing forever. With each new generation of sprouts, the stump becomes more and more weakened, and hence gradually loses its capacity to produce healthy and vigorous sprouts. Although it is impossible to state with certainty how many generations of chestnut can be raised from the same stock without impairing the vitality of the sprouts, the effects of repeated and bad coppicing manifest themselves in the increasing number of dying chestnuts all over Maryland. The immediate cause of their death can nearly always be traced to attacks of either insects or fungi, yet the prime reason is their decreased vitality, which makes them easy prey to their natural enemies.

As stated by Dr. Clinton:[12]

> It is certainly a curious coincidence that the blight makes its first appearance and causes its greatest damage in the regions where the chestnut has suffered most from repeated cutting over.

Dr. Clinton quotes Nellis, of the U. S. Forest Service, who, in an unpublished working plan on "Utilization of Blight-killed Chestnut," writes:

> It is expected that this study will show that the present range of the chestnut bark disease is in a region of entirely second growth chestnut, which has been culled of its most valuable timber, where only rough products are now being produced.

Without entering into the discussion as to the relation of the bark disease to coppiced areas, I will merely state that coppiced chestnut is in general apt to be affected with disease of some sort. Especially frequent are heart-rotting fungi which may enter by way of the decaying parent stump, and the unsound condition of the trunk they cause is communicated to succeeding generations. It is also conceivable that the root system of the sprouts, inasmuch as it is partly that of the parent tree, may be weaker on this account. For, although we have no evidence to prove that the parent root system becomes inherently weaker with age, yet it is reasonable to expect that the soil about it would become more and more exhausted of its nourishment, to say nothing of possible external injuries to which it might be subjected in the course of a long period of time.

As already intimated, forest fires are extremely disastrous to the

[11] Zon, R., "Chestnut in Southern Maryland," Bureau of Forestry, U. S. Dept. of Agric. Bull., 53: 29, 1904.

[12] Clinton, G. P., *loc. cit.*, p. 402.

chestnut, not only by reason of their direct effect where they kill the tree outright, but also by exposing its interior to the attacks of fungi and insects. In addition, such fires impoverish the soil by burning out the humus, thus materially lessening its fertility. Reproduction also receives a setback because seedlings, young sprouts, or nuts lying on the ground ready for germination, are easily killed. Forest fires have been abundant throughout the range of the chestnut tree, and it is reasonably certain that they have been much more frequent since the white man has settled these parts of North America. In the southern Appalachians, the deadly work of fire, followed by insects and fungi, is to be seen on every hand. In this connection the following citations give us some conception of the general condition of the chestnut in the southern Appalachians.

Dr. Mohr,[13] speaking of the chestnut in Alabama, says:

> The chestnut, usually one of the most frequent trees of these forests, is at present rarely found in perfection. The older trees mostly show signs of decay, and the seedlings, as well as the coppice growth proceeding from the stumps, are more or less stunted. It is asserted by the old settlers that this tree is dying out all over the mountainous regions, where at the beginning of the second half of the century it was still abundant and in perfection.

W. W. Ashe,[14] says:

> For many years the chestnut on the lower mountains in the southeastern portion of the state has been dying out, a few trees at a time. . . . Some of these are killed by the two-lined chestnut borer, but while this decline is in part due to the ravages of the borer, it seems to be due more to excessive burning and to the consequent destruction of humus and impoverishment of the soil.

W. P. Corsa,[15] states:

> From causes not well understood, there is a marked decline in the vigor of the chestnut throughout the broad area of territory in the southern states where the white man found this tree among the most thrifty of the original forests. Down to the first quarter of the present century there seems to have been no mention of a trouble in the chestnuts of that section. Within the memory of residents of the Gulf States the chestnut flourished in all their higher lands. In point of time the trouble seems to have begun in the most southern limit of chestnut growth, and there the destruction has been most complete. It has pushed its encroachments throughout Mississippi, Alabama, Georgia and South Carolina, and is now reported in the strongholds of chestnut growth in North Carolina, Tennessee and Virginia.

Buttrick,[16] in a study of the conditions in North Carolina, says:

13 Mohr, Charles, *loc. cit.*, p. 61.

14 Ashe, W. W., "Chestnut in Tennessee." State Geol. Survey of Tennessee, published in cooperation with the Forest Service, U. S. Dept. of Agr. Bull., 10-B, p. 11, 1912.

15 Corsa, W. P., "Nut Culture in the United States." Unnumbered Bull. of Div. of Pomology, U. S. Dept. of Agric., 1896, p. 78.

16 Quoted by permission, from the manuscript of a report on the chestnut in North Carolina, prepared by P. L. Buttrick, under the joint direction of the

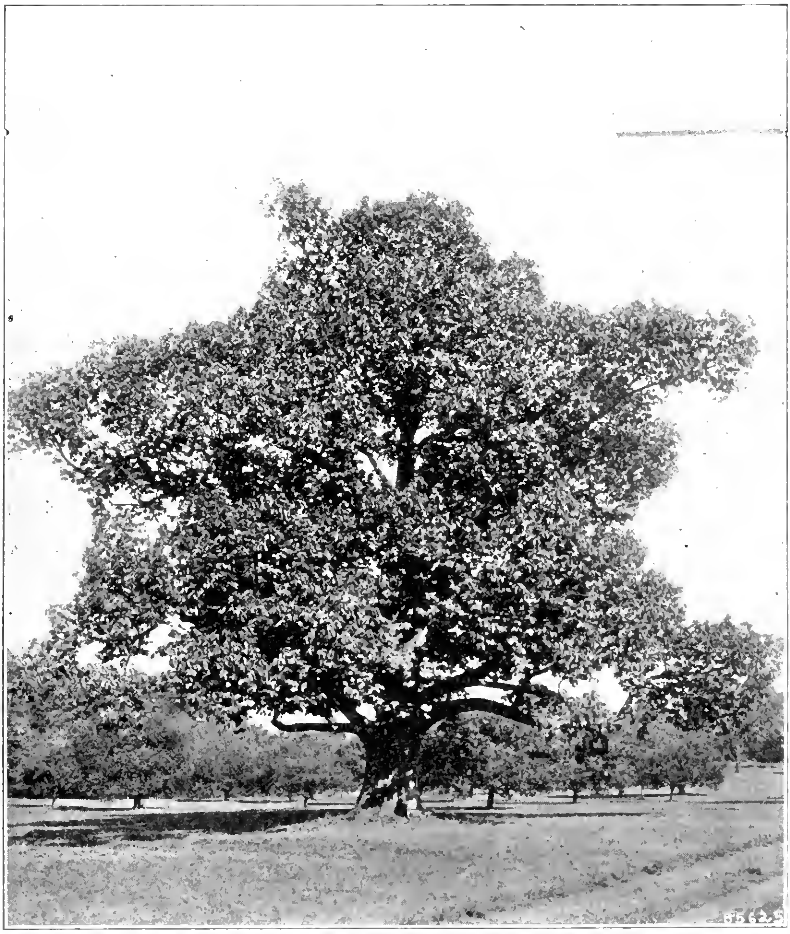

FIG. 2. AMERICAN CHESTNUT, CENTRAL MARYLAND. Photograph supplied by the United States Forest Service.

It is well known that chestnut was much more abundant and important throughout the Piedmont region and at places in the mountains themselves than is the case to-day.

Records show that during the first half of the past century, chestnut formed an important part of the growth forest throughout the western Piedmont section, although probably never as important a one as in the mountains. It was also apparently found much farther east than at present and may have at one time reached the Coastal Plain.

About seventy-five years ago it began to die throughout the eastern portion of the plateau and by the sixties it was dying throughout Guilford county and to the west. In the early eighties it began to die throughout Iredell, and the counties north and south of there. Since then the "death wave," as we may call it, has traveled west and overflowed the Brushy and South Mountains; has reached half way up the slopes of the Blue Ridge, and is still rising in the

Laboratory of Forest Pathology, U. S. Dept. of Agric., and the North Carolina Geological and Economic Survey; and soon to be published by the latter.

northern and has actually crossed it in its southern section. West of the ridge in most of the regions where chestnut is wanting, its disappearance has been quite recent and, indeed, it is still disappearing.

This strange phenomenon is not confined to North Carolina, but is to be seen to a greater or less extent on the outer portions of the range of the chestnut, throughout the southern half of its range. Reports show that chestnut has largely died out or was formerly much more abundant in portions of Virginia, South Carolina, Georgia, Alabama, Mississippi and Tennessee, and that the recession is still going on.

This apparently mysterious decline in vigor of the chestnut in the south is evidently not due to any one factor, but probably to a variety of causes. Probably frequent forest fires are to blame for the beginning of most of the trouble, and these, as we have seen, are followed by the attacks of fungi and insects. The cutting over and clearing up of large areas may also result in soil conditions which are not as favorable as formerly. Climatic changes may also have something to do with the case.

If we summarize briefly the troubles of the chestnut described in the preceding pages, we find that in the northern half of its range it is a prey to the bark disease; throughout its whole area it is attacked by the two-lined chestnut borer, as well as by other insects, and also by fungi which destroy the heartwood. The common practise of coppicing can only be regarded as harmful when carried on for several generations. Forest fires have been frequent, resulting in injuries of many sorts. In the southern states still other factors are evidently at work.

Let us now turn to the other side of the balance sheet, *i. e.*, to the assets of the chestnut, those traits in its life and habits which are of advantage to it in the struggle for existence and the perpetuation of the species.

Of first importance is its rapid and vigorous growth. Among the numerous advantages to be derived from this is the power to close over any chance wounds with new tissue with greater ease than would be the case in a more slowly growing species. And we have already seen how wounds may open the door to disease and decay.

An inherent power for rapid growth also enables the tree to develop roots quickly in times of need, and also, in competition with other species in the forest, to lift its crown above them in order to secure better light. Moreover, in this connection we should recall that the chestnut is fairly "tolerant," *i. e.*, not easily killed out or injured by the shade of older, larger trees.

As regards its soil requirements, we find that, unlike such trees as the tulip or basswood, it is not at all fastidious. Its principal needs seem to be an adequate amount of moisture in the soil, for it appears to be quite sensitive to drought, and also a soil which is fairly deep and loose. As to the chemical nature of the soil it is not particular, except that it rarely grows in a limestone region. Neither need the soil be a fertile one, for chestnut trees grow and thrive on sterile soils, provided they be porous

FIG. 3. AMERICAN CHESTNUT, MITCHELL COUNTY, NORTH CAROLINA. Photograph supplied by the United States Forest Service.

and have a sufficient underground supply of moisture. In the matter of soil requirements, therefore, it is easily suited, and it is hardly necessary to add that this is a distinct asset on the side of the perpetuation of the species.

Just as is the case with other organisms in both plant and animal kingdoms, all our tree species possess an average age limit. Some of the individuals of the species live longer, and others die out before the limit is attained, but to every species one might assign an average length of life. This age limit differs, of course, with different species: for example, some of the oaks are notably longer lived than such species as the aspen or the gray birch. Some of the causes of these differences in longevity are obscure, and this is not the place for their discussion. What we wish to point out is that trees as well as animals, vary in their age limits.

Now, a tree, on reaching maturity, begins to reproduce, that is it forms seeds, which, if they find conditions suitable for them, develop into individuals like their parent. I have here in my yard a silver maple, the seed of which I planted in 1904. Two years ago, in 1912, when it was eight years old, and about ten feet high, it bore a few blossoms and seeds. Last year more seeds were produced than the year before, and this year it is loaded with blossoms. Although still a small tree, not yet ten years old, it is arriving at maturity, and is able to reproduce itself. It should continue to do this until the end of its life. Of course under modern city conditions, where, among other disturbing elements, the ubiquitous lawn mower can always be counted on to do its deadly work, it is a question how many, if any, of its descendants will survive. But, nevertheless, here or anywhere, the *chances* of reproducing its kind depend ultimately on the number of seeds it bears, and this number, again, depends directly on the length of its life.

It is clear then that with two species with differing age limits, other things being equal, the species which is longer lived would have the better chance to perpetuate its kind.

When we consider the genus *Castanea*, we find it especially favored in this respect, for it has long been noted for its longevity. The following extract from Sargent's[17] "Silva of North America" is of interest in this connection:

> The Tortworth chestnut, tree on the estate of the Earl of Ducie, in Gloucestershire, which is still in a healthy condition, was remarkable for its great size in the reign of Stephen, who ascended the English throne in 1135, and is probably considerably more than a thousand years old. In 1776, the short trunk of this remarkable tree measured fifty feet in circumference at five feet from the ground.

Further on, writing of trees on Mt. Ætna, in Sicily, Sargent says:

[17] Sargent, C. S., *loc. cit.*, 9: 8, 1896.

FIG. 4. CHESTNUT TREE, NEAR THE TRAIL TO BUCK SPRING LODGE, PISGAH FOREST, NORTH CAROLINA. This tree measured eighteen feet in circumference. Photograph supplied by the United States Forest Service.

The trunks of two of these Sicilian trees measured sixty-four and seventy feet in circumference: and at the end of the last century the low trunk of . . . the largest of the trees had a circumference of nearly two hundred feet at the surface of the ground. . . . Trees with trunks from twenty to thirty feet in circumference and believed to be at least a thousand years old, are not uncommon in southern Europe, where the chestnut is the largest, and with the exception perhaps of the olive, the longest lived inhabitant of the forest.

The above quotations apply of course to the European chestnut. In North America large trees of the native species are also not rare (Figs. 3 and 4). Although definite data as to their ages are wanting, they show enough for our purpose, namely, that the American chestnut shares in the family characteristic of extreme longevity enjoyed by its European relative.

I have already spoken of the sprouting capacity of the chestnut, and for various reasons have stated that when coppicing is too long continued it can only result harmfully. On the other hand, the sprout-producing ability *per se* should be reckoned as a distinct advantage to the species. We know that when the lumberman fells such trees as the pine or hemlock he sounds the death knell of that individual. On the contrary, in the case of the chestnut, as we have seen, this is just the operation which leads the way to an increase in the number of individuals, for where one tree existed before, now four or five ultimately develop, sprouting from the stump. This kind of "vegetative" reproduction which, eventually, of course, results in increased seed production, is naturally an important factor in prolonging the life of the species. Zon[18] says of the chestnut in southern Maryland:

> Were it not for its sprouting capacity and its frequent occurrences on slopes difficult to till, chestnut in Maryland would be a species of the past, as white oak and several other species are fast becoming.

There is, possibly, another point which may be in favor of the chestnut tree, although it applies only to the southern representatives of the species. As far as we can judge from reports and surveys, the progress of the chestnut bark disease into the southern states has been slow: at least, it has apparently spread into this territory with no such rapidity as has been remarked in the northern states.

Under the circumstances, it is entirely reasonable to assume that some condition exists in the south unfavorable to the development of the blight fungus. Various explanations have been offered, but none of them is more than a hypothesis, since, as far as I know, no accurate scientific investigation of the case has been made.

Perhaps the most plausible theory is to the effect that the southern chestnut may contain a larger amount of tannin than the northern tree and that this higher content of tannin may be inimical to a vigorous development of the fungus. Whether it is actually a fact, however, that a southern tree contains more tannin than a northern tree of equal age, has not been determined. We know that the tannic acid manufacturers use only southern chestnut for their material, and yet this may be simply because larger trees exist in the south, and we know that the older, larger trees contain more tannin. The actual comparative tannin content of northern and southern trees would form an interesting subject for future investigation. Dr. Clinton,[19] acting on the supposition that some such relation as this might exist, has carried on some interesting experiments with the chestnut blight fungus in culture media containing various percentages of tannic acid. He has found, among other

18 Zon, *loc. cit.*, p. 13.

19 Clinton, G. P., *loc. cit.*, pp. 404–407, and pp. 430–434.

things, that while the fungus grew vigorously up to a certain percentage of tannic acid, its development was very sensibly retarded if the percentage was slightly increased beyond this point. If the southern tree actually contains a large amount of tannin we should have here a fundamental barrier to the advance of the chestnut blight fungus, and thus a decided advantage in favor of the southern representatives of the species. However, as I have already intimated, the whole matter is theoretical, since there is entirely insufficient evidence to substantiate it.

If we summarize, then, the points which the American chestnut has to its credit on the asset side of the balance sheet, we find that it exhibits a rapid and vigorous growth, it is fairly tolerant, at least in youth, it is not over particular as regards soil requirements, it enjoys longevity as an inherent characteristic, it reproduces itself by sprouting from the stump, and finally, as regards the trees in the southern section of its range, their supposedly larger content of tannin may prove to be a protective power against the annihilating advances of the bark disease.

This list is impressive—in fact, one could hardly conceive how the species could be more favored, and, indeed, these are undoubtedly the main reasons why it has been so firmly established and abundant throughout its range.

When we review the troubles by which it is assailed on every hand, it is remarkable how many of them are due primarily to man's activities: as, for example, the introduction of the bark disease, continued forest fires, repeated coppicing, change of soil conditions from cutting over large areas, etc. And although through the efforts of a few some of the evils may be checked or diminished, from the complex nature of the case, the deadly work will inevitably continue. One can not avoid the conviction, therefore, that, if the present conditions persist, the virtual extinction of the American chestnut is only a question of time. In the south it is dying out where it once flourished, and in the north its general condition is such that it may soon cease to be classed as an important timber tree. How long it will survive it is of course impossible to predict with any degree of exactness. But at the present rate of decline its future life may possibly be measured in hundreds of years, but not in thousands.

The most hopeful indications for chestnut in North America in the future lie along the line of breeding experiments. Since the blight is our worst enemy, work on the development of varieties immune to this is of the highest value. It has long been known that certain Japanese forms are somewhat resistant to the blight, and the disease is comparatively inconspicuous on the Chinese chestnut, on which it has recently been found.[20] Fortunately work on hybridization of chestnut species had been started long before the blight was discovered in this country. Among

[20] Metcalf, Haven, *loc. cit.*

the investigators in this field, Van Fleet,[21] of the United States Department of Agriculture, crossed Asiatic and European forms with the American chestnuts, the latter consisting of *Castanea dentata*, the forest tree, and *C. pumila*, a shrubby species growing in the southern states. The last species appears, by-the-way, to be somewhat resistant to the blight. Van Fleet says:

> The results of these undertakings have been successful, in the main. The appearance in 1907 among our plantings of the terribly destructive new bark disease organism, *Endothia parasitica*, put a summary termination to the experiments with *C. americana* (*dentata*) and its derivatives, but selection work has since continued with self and chance-pollinated individuals of the chinquapin and Asiatic types. . . . The Asiatic chestnuts, and the chinquapin-Asiatic hybrids, are plainly highly resistant. Few have shown any appearance of infection and when noticeable the injury is quite local in character. Second generation seedlings of chinquapin-crenata crosses show no disease at all although always exposed to infection.

The nuts produced by these chinquapin-Asiatic hybrids are of decidedly superior quality, so that, if they continue free from disease, they will solve the problem from the standpoint of the chestnut orchardist. It is doubtful, however, whether they will ever attain the size of forest trees. But it is quite possible that an immune variety for timber purposes may be produced by crossing a form like the Chinese chestnut, *C. mollissima*, with our native forest tree.

Work of this kind is extremely valuable and, although slow in yielding results, may eventually prove to be the only means of continuing the existence in our land of a greatly esteemed tree.

[21] Van Fleet, Walter, "Chestnut Breeding Experience," *Jour. of Heredity*, 5: 19–25, 1914.

# CLAUDE BERNARD

By D. WRIGHT WILSON

ONE hundred years ago, in a little village in eastern France, there was born of humble parentage a man who was to become one of the greatest physiologists of France and of the world. Though a pioneer in a field despised and looked down upon at the time, he was to make discoveries which were of fundamental importance to physiology and medicine and were to influence the whole general aspect of biology toward certain questions.

Claude Bernard was born in the little village of Saint Julien, department of Rhone, July 12, 1813. His father was a small land owner of the district and earned a comfortable living from the fruit of his vineyard. Bernard later came into possession of the estate and spent his vacations there, working out of doors among his trees and vines. He describes it thus:

My dwelling is on the hill slopes of Beaujolais which look toward the Dombe. The Alps give me my horizon and when the air is clear I catch sight of their white summits. At the same time I see spread out before me for two leagues the prairies of the Saône. The slope on which I dwell is surrounded on all sides by vineyards stretching away apparently without limit; these would give the country a monotonous appearance were not this broken by wooded valleys and brooks running down from the mountains to the river. My cottage, situated though it is on a rise, is a very nest of verdure, thanks to a little wood which shades it on the right and to an orchard which flanks it on the left; a great rarity in a land in which they stub up even the coppices in order to plant vines.

Bernard and a sister were the only children. He was apparently a bright child, for the curé made him a choir boy and taught him Latin. Later, he went to the small Jesuit college at Villefranche and from there went to Lyons, where he soon left school to enter a practical pharmacy. At first he received only board and lodging for his services, but soon his manual dexterity won for him a small salary. He remained here two years, but his employer's mode of business made him sceptical of medical and pharmaceutical practise of the day as shown by the following story related by Sir Michael Foster.

As was usual at that epoch the clients of the shop, especially the old women of the outlying vilages, made a constant demand for a syrup which seemed to cure everything; and Bernard, to his astonishment, found that this favorite syrup was compounded of all the spoilt drugs and remnants of the shop. Whenever Bernard reported a bottle of stuff had gone wrong, "Keep it for syrup," replied the master; "that will do for making syrup."

Bernard had literary aspirations, being especially attracted toward the drama, and spent much of his time at the Théâtre des Célestines. He wrote a vaudeville comedy entitled "La Rose du Rhône" which was accepted and attained a fair degree of success. Thus encouraged, he started in earnest to write a five-act historical drama in prose and determined to seek his fortune in Paris. On reaching the city, in 1834 when

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he was twenty-one years old, he presented his manuscript of "Arthur de Bretagne" with a letter of introduction to the great critic, Saint-Marc Girardin, who received him kindly and saw that the work possessed merit, but, knowing the uncertainties of a writer's life, suggested that Bernard take up some work whereby he could make a living. Hearing of his former pharmaceutical training, Girardin suggested that he study medicine. Bernard followed the suggestion and, for five years, applied himself to the work. He was especially interested in anatomy and physiology. Anatomy, at this time, was well advanced and scientifically presented but physiology consisted of a mass of uncorrelated and inexact data.

His father died during this period, having lost most of his fortune before his death, and left Claude to depend on his own resources. He lived frugally and payed his fees with money earned by giving lessons. He was retiring, thoughtful, awkward in manner and impressed neither his fellow students nor his professors as being brilliant or liable to a great career. Only in the dissecting room did he attract attention by his careful and beautiful dissections.

In 1839, after serving as "externe" at the hospitals, he was made "interne" and appointed to work under Magendie, who was one of the physicians at the Hotel Dieu and professor of medicine at the Collège de France. The professor was allotted a small, dark room at the college for conducting research and was allowed a "préparateur" to assist in research and in experiments conducted to illustrate the lectures. He soon noticed Bernard's skill in dissection and appointed him his "préparateur." With this appointment, Bernard's career as experimental physiologist began. A glance at the state of physiology at this time will show the great odds against which he was about to work.

The spirit of present-day research was only beginning to be allowed full play. Harvey, early in the seventeenth century, opened the way for the application of experimental methods to physiological inquiry by his observations leading to the discovery of the circulation of the blood; but the vitalistic theory had impeded, at every step, the attempts to study living organisms. Slowly, this theory was losing ground and physico-chemical explanations substituted.

The spirit of progress was most apparent in Germany. Liebig had recently opened at Giessen the first public laboratory for chemical research. Wöhler had made urea from ammonium cyanate, thus destroying the old vitalistic argument that life was necessary to form organic from inorganic substances. Johannes Müller was the foremost physiologist. He was a vitalist, but only in a modified degree much more acceptable than Haller and his pupils. He believed in the necessity of recognizing a vital force, but maintained it was not independent of certain conditions. He did not depreciate the value of the experimental method in discovering physiological truths, as is shown by his own work and that of his pupils, among whom Ludwig, DuBois Raymond and Helmholtz, soon to be the foremost physiologists in Germany, were just beginning their careers.

In England, Hall, Reid, Sharpey and Bowman were advancing the science by experimental methods.

France had looked too much to her own scientists for the words of progress and was far behind her neighbors. Cuvier and Bichat were especially popular. Cuvier, a morphologist and an ardent vitalist, was supreme and depreciated any attempt to explain or solve physiological problems by physico-chemical means. Bichat, though long dead, was very powerful and his explanations which were finally to overthrow the vitalistic conception had been misunderstood and misapplied to over-emphasize it. Many scientists of the time asserted that living organisms could not be subject to exact experimentation.

Magendie was the foremost physiologist in France and believed in a modified vitalism. While he paid his respects to vitalism by admitting that some of the phenomena of life were beyond the scope of experimental investigation, he realized that physico-chemical explanations could solve many problems of physiology. Disgusted with the empty discussions of the vitalists, he went to the other extreme and threw his energies entirely into experimental study without thought or plan, and though his accomplishments were many, they fell far short, considering the time spent and energy consumed.

Bernard saw the fallacies of each line of endeavor and, at the outset strove to use all his powers of theoretical and practical reasoning, together with careful manipulation and observation. Besides his work at the college, he gave a course of private lectures and spent the remainder of his time at research, usually in some temporarily improvised private laboratory or in the chemical laboratory of some one of his friends. There was no room for his private research at the Collège de France.

In May, 1843, he published his first communication: "Recherches anatomiques et physiologiques sur la corde du tympan, pour servir à l'histoire de l'hemiplégie faciale," followed in the same year by his doctor's thesis—"Du suc gastrique et du son rôle dans la nutrition." The work on the chorda tympani nerve, suggested by Magendie's work on nerves, started a long series of similar studies. This was typical of his analytical and logical reasoning. He proceeded, step by step, in his experiments to their logical conclusion or until an observation suggested a separate line of inquiry which seemed to be more fruitful. His thesis on the gastric juice was also the first of a series which led to his great discovery of glycogen and the glycogenic function of the liver. The main result of this thesis was that cane sugar, injected into the blood, was excreted unchanged; but sugar which had previously been acted upon by gastric juice was not excreted when injected, but was retained and used by the tissues. These two pieces of work illustrate Bernard's line of thought. He was always interested in the action of the nervous system on the chemical changes involved in nutrition and worked from both the physiological and chemical aspect of the problem whenever possible.

In studying the difference in the digestion and nutrition between carnivora and herbivora, he noticed that fat fed to rabbits was digested and absorbed much lower down than was the case when it was fed to dogs, and soon found that the variation was due to the different points of entrance of the pancreatic duct into the intestine in the two animals. This led to a long series of experiments on the function and properties of the pancreas. He showed for the first time that the pancreas and not the stomach was the chief organ of digestion and that the gastric juice merely started the digestion which was completed by the more powerful pancreatic juice. Its three-fold function for digesting proteins, fats and carbohydrates was also demonstrated. For this work, which was reported in 1848–9 and published complete in 1856, Bernard was awarded the prize of experimental physiology by the Académie des Sciences and was introduced to the scientific world as a physiologist of remarkable ability and great promise.

The story of the discovery of glycogen, which revolutionized prevalent biological theories concerning functions of the organs and differences between plant and animal metabolism, is interesting in showing how a quick, alert mind can "grasp the hints that Nature gives" and advance, step by step, to a final realization of the complete truth.

The prevalent view concerning the differences between plant and animal metabolism had been proposed by Dumas, the chemist, and Boussingault, the agronomist. They showed that plants build up complex organic compounds from inorganic substances and animals, by feeding, take the complex compounds already formed and break them down to simpler ones. Animals might modify them, but never make them more complex. There was a complete cycle in which compounds were built up by plants and broken down by animals. While this was the prevalent view, there were some strong minds who opposed it. Liebig confirmed Huber's old observation that bees, fed on sugar alone, produce wax and showed that fattening geese accumulate fat in excess of the fat fed.

Bernard proposed to trace the successive steps by which the various food-stuffs are transformed in the body and chose sugar as the subject for his first investigation because it seemed liable to the simplest explanation. The other foodstuffs were never investigated. He was early interested in diabetes and wished to find the cause for the excess of sugar in the blood and thereby assist in working out a remedy. His plan was as follows:

He had shown that cane sugar must be changed before it can be retained by the blood. Tiedemann and Gmelin had proved that starch is changed to sugar before it is absorbed from the alimentary tract. This indicated to him that all carbohydrates enter the blood as simple sugars. Where was this sugar destroyed? If he could find the tissues that caused the destruction and by some means decrease their activity, the blood would become overloaded with sugar and experimental diabetes would be produced. Thus, the discovery which he made was not the result of a "haphazard dive in Nature's full pocket" but came from a carefully planned experiment. As was often the case, the investigation did not yield the expected results, but something equally valuable.

He fed a diet rich in sugar to a dog, killed it at the height of digestion and examined the blood leaving the liver by way of the hepatic vein to see if the liver caused a destruction. An abundance of sugar was found here. To see if this was the sugar which had been fed, the experiment was repeated, giving the dog only meat. To his great surprise, an abundance of sugar was again found in the hepatic vein and very little in the blood from the other organs. He immediately divined the truth that the liver makes the sugar which was found in such large amounts. Repetition of the experiments with many modifications always produced the same results. The sugar was shown to be dextrose. Different animals showed the same phenomenon. These results were published in 1849–50, when he described the sugar production by the liver as similar to a secretion and not influenced by the kind of food eaten.

These observations, confirmed by others, established the glycogenic function of the liver; that is, they proved that the liver produces sugar by a mechanism similar to secretion. Going further, he showed that the sugar is not made from substances in the blood flowing through the liver, but from a substance present in the liver tissue. This was demonstrated by washing out all the blood and sugar from an isolated liver. After letting it stand for some time in a warm place, more sugar could be washed out with water. Boiled liver tissue did not react in this way, but if a small amount of fresh liver decoction was added to the boiled tissue, sugar was produced as before. This experiment showed that the sugar was formed by enzyme action from something present in the liver tissue. He isolated this substance and showed it did not give the tests for dextrose, but was easily changed into it by fermentation. These results were announced to the Académie des Sciences on September 24, 1855. Two years later, he obtained the substance in a pure state and gave it the name "glycogen." Analysis showed it to be a carbohydrate.

Bernard believed the formation of glycogen in the liver to be a vital process, but the formation of dextrose from glycogen to be a simple enzyme action independent of life. This was contrary to the teaching of the time, for all enzyme actions were considered to be inseparable from the living cell. He showed that the blood contains an enzyme capable of forming dextrose from glycogen and suggested that a nervous control of the circulation governs the sugar formation. Comparisons were drawn between the formation of glycogen and sugar in the animal body and starch and sugar in plants.

While work was continued along this line, the fundamentally important results have been mentioned above. Other experiments and writings confirmed, extended and defended his views. Bernard had made a great discovery and pushed it to the end and did not have to suffer the humiliation so often falling to the lot of a pioneer who pronounces a great fundamental truth and is outstripped by his contemporaries in producing proofs and developing details. Though it took several years to work out all the details, he always kept the lead.

This discovery supplied much that had been obscure concerning the sugar metabolism in the body and the functions of the liver, and greatly influenced general biological thought. It overthrew the idea that animals can not construct but only destroy products built up by plants. It broke down the prevailing theory that each organ has only one function. Previous work had shown that the liver produces bile and the pancreas and stomach furnish digestive juices. Nothing more seemed left to be learned except the function of the spleen. The discovery of the second function of the liver destroyed the bonds which the theory of functions had thrown around the biological thought of the time and encouraged more work in this field. The introduction of the idea of an internal secretion which was poured into the blood to assist in the normal nutrition of the body has been very productive and still fills the minds of physiologists and bids fair to produce some of the most valuable contributions to modern physiology.

Glycogen was soon found in all the tissues and quantitative relations were investigated. Others have contributed but little new to the subject and Bernard's ideas stand to-day as he expressed them then.

> He, in the matter of glycogen, not only laid the very first stone, but left a house so nearly finished that other men have been able to add but little.

During this work, Bernard discovered the remarkable fact that a puncture of the fourth ventricle of the brain causes temporary diabetes. This, like other of his discoveries, was not happened upon accidentally, but was the result of logical reasoning concerning the nervous control of the sugar production by the liver, which he assumed to be a typical internal secretion. He found that cutting the vagus nerve stopped the sugar production and reasoned that stimulation of the nerve should lead to increased production. Being unsuccessful when all the ordinary means of nerve stimulation were used, he resorted to an expedient which he had noted previously, that a marked stimulation occurred when the point of origin of the nerve in the brain was punctured. In this case, an over-production and excretion of sugar was obtained. Here, as in a number of instances, a wrong view led him to an important discovery for he soon showed that the vagus is not a true secretory nerve governing the hepatic sugar secretion.

This illustrates one of Bernard's important characteristics. He developed a line of theoretical reasoning to its fullest and, by watching his experimental evidence, could grasp whatever facts showed themselves unbiased by the reasoning which had suggested the experiment. He emphasized imagination and preconceived theory when used in their proper places and used to say:

> Put off your imagination as you take off your overcoat when you enter the laboratory; but put it on again, as you do the overcoat, when you leave the laboratory. Before the experiment and between whiles let your imagination wrap you round; put it right away from yourself during the experiment itself, lest it hinder your observing power.

His discovery of the vasomotor nerves was hardly less important than the discovery of glycogen. These nerves control the circulation of the blood by causing the muscles in the walls of the blood vessels to increase or diminish the bore thus allowing more or less blood to flow through at one time. The nerves belong to the sympathetic system, that is, they are not under the control of the will but stimulated by sensory impulses. The part played by him in this work was different, for he did not realize the importance of his discovery. As usual, he was looking for something else, and did not immediately turn aside to follow the new line of work.

The knowledge of the blood vessels at this time was very limited and inexact. Johannes Müller, the foremost physiologist in Germany, in his classical work on physiology in 1838, concluded that the arteries did not possess a muscular coat but only physical elasticity. He was entirely unprepared for the idea of vasomotor nerves. The sympathetic nerves had been traced to the blood vessels and some thought they should have something to do with the circulation. Stilling introduced the word "vasomotor" in arguing from theoretical grounds that the circulation must be governed by nerves not subject to the will, but influenced by sensory stimuli. In 1846, Kölliker discovered that plain muscle was made up of minute spindle-shaped cells either in clumps or scattered. This cleared up the doubts concerning the muscle coat of the blood vessels. The way was now open for the proof of the vasomotor nerves, but no one saw it.

Bernard proposed to study the influence of the nerves on animal heat, and began by attempting to ascertain the effect of cutting a sympathetic nerve on the temperature of that part of the body affected by it. He conceived that the action of the nerve, if any, would be in governing the chemical changes involved in heat production, and expected to find a section of the nerve would cause a lowering of temperature. Working on the cervical sympathetic nerve in a rabbit, he was astonished to find an increase instead of a diminution in heat on the side of the head where the section was made. He reported:

All the part of the head that becomes hot after section of the nerve becomes also the seat of a more active circulation. The arteries seem fuller and appear to pulsate more forcibly; this is distinctly seen in the case of the rabbit in the vessels of the ear.

He reserves for further consideration "whether the vascular changes are the cause or the effect of the rise of temperature." While the work was published as experiments on animal heat, it is the first clear and decided experimental proof for the vasomotor functions of nerves. The operation had been performed for one hundred and fifty years and the constriction of the pupil of the eye had been noticed, but the increased heat and the dilatation of the arteries had never before been observed. With this experiment, the true knowledge of vasomotor nerves begins.

This discovery caused a great stir in the scientific world and several investigators proceeded to work on the subject independently. Brown-Sequard proposed the correct interpretation of the phenomena that section of the nerve caused a dilatation of the blood vessels and the dilatation allowed increased blood flow which resulted in an increase in temperature and irritability. Bernard held continually that part of the heat effect might be due to the influence of the nerves on the chemical activities in the tissues.

Several years later, working on the submaxillary gland, Bernard observed that the blood coming from the gland was bright red, like arterial blood when the chorda tympani nerve was stimulated, and that it was dark, venous and small in quantity when the sympathetic nerve was stimulated. Thus, he showed that the chorda tympani is a vasodilator nerve causing dilatation and increased blood flow, while the sympathetic is a vasoconstrictor nerve. This effect was shown to be true for other glands. This was the first clear announcement of the presence of vasodilator and vasoconstrictor nerves.

Other lines of work occupied his attention, but the results do not possess such fundamental value as those described above. He worked on the physiological effects of curare, the arrow poison of the South American Indians. Carbon monoxide poisoning was explained as due to a stable combination of the gas with the red blood corpuscles. This explanation was made before respiration had been explained as due to an unstable combination of oxygen with the hemoglobin of the red blood corpuscles. He presented a proof against the spontaneous generation of life when that question was a vital issue in the scientific world. He carried out some work on fermentation opposing Pasteur's views that the living cell is necessary, thus anticipating Buchner's proof by twenty years.

Bernard began work when opportunities for research were scarce and his chosen field was looked down upon and scoffed at, but he persisted despite the obstacles in his way. In 1847, he was appointed a deputy at the Collège de France and a career seemed assured. He now could work in an official laboratory. He said at the beginning of his lectures:

> Scientific medicine, gentlemen, which it ought to be my duty to teach here, does not exist.

Four years later, he was much disappointed in his career and thought of giving up scientific work and going into private practise. Unhappy domestic relations made matters worse, for his wife had no sympathy for his scientific endeavors. He was, however, beginning to be recognized as a coming man in science and was given the newly created chair of general physiology in the University of Paris at the Sorbonne. This was the first honorable position for him to occupy and his devotion to science was now assured. In the same year, he was elected to the Academy of Medicine and Surgery. In 1855, Magendie died and Bernard took his place as professor at the Collège de France.

The lectures were not specified at the college, so he usually chose some topic on which he was working and developed it, from lecture to lecture, illustrating with old and new experiments. He used his lectures to make known new facts and new or corrected and extended views. The reports which were made to the Académie des Sciences and the Société de Biologie were very brief and incomplete. Only in his published "Leçons" is a full account given of his experiments and results, many of which are found there alone. They were reported by one or another of Bernard's students, revised by him and published. These are his greatest written contributions. The series began with "Leçons de Physiologie expérimentale," published in 1855, dealing with the physiology of sugar and the glycogenic function of the liver. He published seventeen volumes in all.

In the winter of 1862–63, he was bothered with an abdominal trouble, probably appendicitis, from which he did not recover for five or six years. Part of the time he spent at his old home at St. Julien tending his gardens and living out of doors. Here he had an opportunity to broaden and generalize his ideas and write an "Introduction to the Study of Experimental Medicine." In his later years, his thinking became more general. He always tried to show the true spirit of physiological inquiry and to realize the general aspects of the whole field. This is well shown in his lectures on the phenomena of life common to plants and animals.

In 1864, he visited court and greatly interested Emperor Louis Napoleon, who entered into a lively discussion with him which lasted for two hours, and was so well pleased that he ordered his minister of public instruction to see that he had whatever he wanted. Bernard obtained in this way two well-furnished laboratories, one at the Sorbonne and the other at the Jardin des Plantes, where he held the chair of general physiology. Thenceforth, his life was full of distinction and honor. In 1868, he was elected to the Académie Française and became one of the "Immortals."

He was separated from his wife and children and lived by himself on the Rue des Écoles, opposite the chief entrance to the Collège de France. He was always retiring and shrank from social distinctions. Foster thus describes him:

> Tall in stature, with a fine presence, with a noble head, the eyes full at once of thought and kindness, he drew the look of observers on him wherever he appeared. As he walked in the streets passers by might be heard to say, "I wonder who that is; he must be some distinguished man."

He was a great friend of Berthelot, the chemist, and Renan, the philosopher, both of whom were his colleagues at the college. His pupils worshiped him.

Bernard was seized by a chill in the laboratory, developed an acute affection of the kidneys, and died, after a lingering illness, February 10, 1878. He was accorded a public funeral at the expense of the state, an honor previously bestowed upon none but statesmen, princes and soldiers. France paid her highest tribute to this quiet man of science who had contributed much, by fact and inspiration, to the advancement of the knowledge of physiological phenomena.

What were the attributes of mind and character which made Bernard a genius as an investigator?

His conscientious adherence to truth at all times need not be emphasized, as that is necessary for all true scientists, great or mediocre. His greatest attribute may have been his fruitful imagination, always under control, active before and after an experiment and asleep when observations were being made. Imagination is necessary to produce original hypotheses and it must be tempered with judgment to produce hypotheses capable of being put to experimental test. Bernard considered none but those of practical value, capable of being proved right or wrong. His readiness to turn aside from a line of research to take up a new inquiry suggested by some observed fact was remarkable for its frequent though opportune use. When to turn aside and when not to do so demands the mind of a genius for solution.

A thing of practical importance and of great value to him was his manual dexterity. In such experiments as some of his, a poor dissection or bunglesome manipulation might easily have complicated the experimental conditions so that the results would have been difficult of correct interpretation and a false step at any point might have led him astray.

It has been said that Bernard has not influenced scientific thought and stimulated investigation as others have, for he so nearly completed the work suggested by his great discoveries. However true that may be in a limited sense, the statement is unjust, for, as with all important scientific discoveries, the effect produced indirectly on scientific thought can not be estimated. He was the first to prove beyond a doubt that animals can build up as well as break down complicated products in the course of their normal nutrition. Few ideas have been more stimulating than this and it undoubtedly greatly influenced thought which subsequently led to the proof of the synthesis of fat and the discovery of the complicated process of protein metabolism whereby protein foods are broken down and built up in the body. Destruction of the theory of functions encouraged further work on the various organs of the body. Since then, many valuable facts have been produced showing the close interrelation of functions of the organs and their interdependence on each other for normal activity. The discovery of the vasomotor nerves opened up an entirely new conception of the regulation of circulation and temperature. It has been of untold value in explaining physiological and pathological phenomena concerning this, one of the most fundamentally important functions of the body. Medical science has applied it to practical problems and made the knowledge of vasomotor activity indispensable to the practising physician.

Taken altogether, his work produced results which greatly advanced knowledge of physiological phenomena, placed physiology among the great sciences, and opened new lines of inquiry which yet promise to bear fruit of which his fertile imagination could not conceive.

# THE GENERAL PHYSICO-CHEMICAL CONDITIONS OF STIMULATION IN LIVING ORGANISMS

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It is customary to say that *irritability,* or the capability of responding to stimuli, is an essential characteristic of living beings. Whether this is true or not of the lowest organisms—certain bacteria or the filterable viruses—there is no doubt that it is preeminently so of the higher, and especially of those leading free and active lives, like most animals. If this were not the case it is difficult to see how such organisms could maintain themselves in their surroundings and continue to behave as living beings—*i. e.,* show their characteristic activities, grow, and eventually reproduce themselves. At least it is clear that in order to do this they must *react* to the changes continually taking place in their particular environment in such a way as to favor their continued existence in that environment; if, for instance, any animal failed to respond to the presence of food—material that can serve it as source of energy—by capturing and incorporating enough to replace its own normal loss of substance, quite obviously its life would soon come to an end. And if it reacted in the same way to the poisonous or otherwise injurious substances in its surroundings as to food, and incorporated both classes of material indifferently, the same result would follow. Evidently there is needed some power of active and selective response to the changing conditions of the environment if the living organism is to continue to live; it must preserve a certain equilibrium with its surroundings; the materials and energy which it appropriates from those surroundings must in the long run at least equal those which it inevitably loses to them in the normal course of its vital processes. This is the physiological interpretation of Spencer's dictum that all life involves a continued adjustment between internal and external relations. The organism must continually alter its activities in correspondence with altered conditions in its surroundings, and in such a way as to preserve this adjustment—avoiding conditions likely to disturb or destroy the vital equilibrium and tending to place itself in those favorable to its continuance. Accordingly, we may say that living organisms in general, and especially animals, exhibit two broad classes of reactions, first those of a defensive or protective kind, including avoiding reactions and inhibitions of various kinds, and second, the more active group of what we may call self-seeking or acquisitive reactions; of these the chief are the reactions of food-seeking, by which the necessary supply of transformable energy and of building material is secured. Both kinds of reactions are equally responses to stimulation; and both are alike physiologically indispensable. In fact, the characteristic self-conserving or regulatory power of organisms, without which they could not continue to exist, depends essentially upon their ability to respond in this way, *i. e.*, upon their irritability.

It is thus apparently not difficult to understand the general biological significance of irritability. What is still largely obscure, however, is the physico-chemical nature of the mechanism which renders possible the response of an organism to stimulation. Physiological experimentation has enabled us to simplify the problem to some degree. We find that not only the intact living organism, but many of its isolated tissues and even cells, react in characteristic ways to stimulation. This is especially true of the tissues that subserve the motor activities of the animal, the muscles, nerves and sense organs. Thus the problem of the nature of the stimulation-process becomes one of the general problems of cell-physiology, and may be stated as follows: What are the essential physico-chemical peculiarities that render the irritable elements of these living tissues so sensitive to stimulation? and what is the physico-chemical nature of the process of stimulation itself? These are the questions which I shall attempt briefly to discuss in this paper. Any answers which can be given at present are incomplete and in part provisional. But recently some definite progress—as it seems to me—has been made toward their solution, and I shall try in what follows to give some account of this recent work and of the more important general conceptions to which it has led.

We have first to define more clearly what we mean by "stimulus" and what by "response." We find on reflection that it is a difficult matter to formulate definitions that are at once exact enough and comprehensive enough to characterize adequately all of the highly varied phenomena included under these terms. We may perhaps best define a *stimulus* as some change of condition that arouses a previously quiescent tissue or organism to activity, or appreciably modifies the activity of one already active; and the response as the resulting activity or change of activity. In many cases the response may be *negative* in kind; *i. e.*; the previous activity may be decreased or completely arrested; inhibition is in fact a very frequent mode of response and one perhaps fully equal in importance to the more positive or active modes as a means of biological adjustment. But what is perhaps the most characteristic peculiarity of the relation between stimulus and response is the fact that there is, broadly speaking, no definable relation of an energetic kind between the two. One of the most striking and distinctive features of stimulation is that an external event or change of condition which causes directly a very slight alteration in the irritable system or organism may yet arouse in the latter a process or series of processes in which the transformation of energy may be almost indefinitely large—out of all proportion to the exciting stimulus. We have therefore first to inquire into the general nature of the conditions that render possible such disparity between the stimulus—considered by itself as a particular chemical or physical process acting upon the irritable tissue—and the resulting special activity or response on the part of the tissue itself.

As all know, an irritable tissue like a nerve or muscle may be aroused to activity under the most various conditions; the effective stimulus may be an electric shock, a chemical substance, the action of light, change of temperature, loss of water, mechanical impact; and the tissue gives the same response to all of these. Now it is clear that such a stimulus can only act as some kind of a *releasing* agency—what Ostwald calls *Anlass*—which sets going some process all of the necessary conditions of which are already present, but which is held in check by some restraining condition which the releasing agency removes—as when a gun is fired, or an alarm-clock set off, or a mine exploded by the pressure of a button—which closes an electrical circuit, thus enabling a spark to pass, which raises the temperature of the explosive to the critical point. The connection between *Anlass* and resulting event may be highly indirect, and there need be no resemblance or other relation than that of interconnection between the two. In all cases the system is, as it were, "wound up"; the potential energy is there, ready to become kinetic; once the process is started or activated by the releasing event, it proceeds of its own accord to its conclusion, *i. e.,* till a second state of equilibrium is reached. In the case of a living irritable tissue or organism we are evidently dealing with a physico-chemical system belonging—as regards the relations between the initiating conditions and the resulting process itself—to this general class. If we press the end of a nerve connected with a muscle, or pass through it an electrical current of sufficient intensity for a sufficient length of time, or dip it into a solution of some appropriate chemical substance, there is initiated at the site of stimulus a "physiological" process which is propagated with unaltered intensity along the nerve to the muscle and there calls forth a complex variety of interdependent physical and chemical changes, of which the contraction is the most conspicuous and physiologically important. Thus a process specific to the tissue, unique and obviously highly complex, is initiated by the relatively insignificant change which the stimulus causes directly. We ought particularly to note that in any special tissue the physiological process remains the same in kind, whatever the nature of the stimulus. The latter merely causes some critical or releasing change which initiates the physiological sequence of events; the latter then proceeds automatically in its characteristic way to its conclusion.

Let us now consider more particularly the physiological part of the whole series of processes—*i. e.,* the response of the living system to stimulation. First we must note that since in any special case the response as a whole is constant, all of its single component stages or separate processes must also be constant, both in their character and their interconnections. There must therefore be some one constant initial process which is directly caused by the external event or stimulus, and upon which the others automatically and inevitably follow. This initial process thus constitutes the critical or activating event in the physiological sequence. It alone is directly dependent on the stimulus; the others are dependent upon it. What is remarkable is that it should be produced by such a variety of different agents. The problem first to be considered may therefore be put somewhat as follows: What is the nature of the initial change produced in the irritable living tissue by the action of the external agent, and how does it happen that it can be caused by such diverse agencies? This problem has evident relations to a wide group of physiological and psychological problems; thus the question of the basis of the "specific energies" of the special sensory apparatus belongs here. In this case also the response—the conscious affective state or sensation—is distinctive and its quality independent (within certain limits) of the character of the stimulus. This is in fact characteristic of all cases of stimulation. How this can be possible I shall now attempt to indicate.

Let us take the case of the simplest of the irritable tissues of higher animals, one in which the excitation-process occurs in a highly characteristic form, but unaccompanied by highly specialized physiological effects like contraction or secretion. Such a tissue is nerve. What are the essential features in the response of this tissue to stimulation? It is first to be noted that the process set up by the external stimulus is *self-propagating*. The disturbance, whatever its nature, which originates at the point of stimulus is of such a kind that it imparts a stimulus to the adjoining regions of the nerve beyond the original point of stimulus; these on becoming active stimulate the next stretch of nerve, and in this way the state of excitation passes along the entire nerve to its termination. Evidently there is an active change of some kind, forming an essential component of the local nerve process, that acts as stimulus to adjoining regions. Now there is no mechanical change in a nerve as the impulse passes, little or no production of heat,[1] apparently a slight physical or chemical change involving a loss of carbon dioxide; but none of these is in itself sufficient to act as stimulus. There is, however, another definite physical change which has this power: namely, the electrical variation—the bioelectric process or action-current—which always accompanies the activity of a nerve or indeed of any other irritable tissue.

[1] Such, *e. g.*, as causes the transmission of the chemical change along a train of gunpowder.

The stimulated region undergoes a rapid change of electrical potential, becoming externally negative relatively to its resting condition; the neighboring still inactive regions being thus positive relatively to the active region, the conditions for the flow of an electrical current between stimulated and unstimulated regions arise. This current is undoubtedly of sufficient strength to stimulate the tissue for some distance beyond the immediate site of stimulation. The voltage of the action-current of frog's nerve is at least thirty millivolts; and a current between platinum electrodes two or three centimeters apart differing in potential by this degree is amply sufficient to stimulate an irritable nerve. The conditions when the two regions of different potential are not externally applied electrodes but portions of the nerve itself are not essentially different; in either case a current flows along the nerve; and if this current is intense enough and arises suddenly enough it must stimulate the latter. There is thus reason to believe that the electrical variation accompanying stimulation is the main condition of propagation of the excited state. This conclusion is supported by various experimental facts; for instance, it is found that the rate of development of the electric variation and the rate of passage of the impulse are influenced to the same degree by changes of temperature, and by certain chemical substances such as the anesthetics. There are various other facts pointing in the same direction, and there are also certain difficulties in the way of this conception; but into these we cannot enter here. The fact remains that the electrical variation is the only known peculiarity of the local process that can account for its self-propagating character; and recent determinations of the minimal current needed for excitation indicate that the bioelectric currents are of sufficient intensity to serve as the basis for this propagation.

It is clear that propagation of the state of excitation from the immediate site of stimulus over the entire cell or nerve fibre is indispensable to stimulation of any irritable element as a whole by any local stimulus; so that if the above view is correct we must regard the electrical variation as perhaps the most essential feature of the stimulation process. If so, we can understand why the electrical current has such universal stimulating action. In passing a current through a tissue we are artifically setting up differences of electrical potential between different portions of the irritable elements, and according to the above conception this should always cause excitation if the current is strong enough and rises to its maximum with sufficient rapidity. That this is in fact the case needs no emphasis. The electrical current is recognized as the most universal form of stimulus; and all irritable cells and elements, virtually without exception, respond to its action.

We conclude then that the critical or initiatory event in stimulation is an electrical change, consisting essentially in a sudden decrease in the electrical potential of the external surface of the irritable element at the site of stimulation; a difference of electrical potential is thus set up between one portion of the irritable element and another. The problem thus becomes clearer: how is it possible that, *e. g.*, a slight mechanical pressure, or the action of a chemical substance or ray of light, may have this effect on an irritable tissue—*i. e.*, may cause a negative electrical variation and so stimulate? and why do electrical changes, of all the processes in nature, bear this distinctive relation to stimulation?

The answer to these questions is far from complete at present, and their consideration brings us at once to some of the most fundamental questions of general physiology. All of the evidence indicates that the bioelectric processes are of critical importance in the life of the cell; they are associated with the most various physiological activities, and accompany the process of stimulation in all irritable tissues; and it is clear that we must understand their controlling conditions before we are in a position to answer the above questions. Now there is one very general peculiarity of living cells which is intimately connected with their power of responding to stimuli—namely, the possession by the surface-layer of protoplasm of peculiar properties in relation to the diffusion of dissolved substances. Living protoplasm is an aqueous solution, chemically complex and containing a high proportion (10–20 per cent.) of colloidal substances, chiefly proteins and lipoids. Experiment has shown that not all soluble substances readily enter the protoplasm of living cells; thus neutral salts like NaCl, sugars and amino-acids (the chief elementary constituents of proteins) diffuse into unaltered cells with difficulty if at all; the surface-film of the protoplasm typically acts toward such substances as a semi-permeable membrane. It is for this reason that the cells of plants remain during life turgid or distended with water, often under high pressure. Osmotic effects, dependent on the semi-permeability of the protoplasmic membranes, are the direct cause of this turgor. The living cell, in other words, is typically enclosed by a modified protoplasmic surface-film or membrane, the plasma membrane, which allows water to pass readily but not dissolved substances of the above kinds. The presence of this membrane makes it possible for the dissolved substances within and without the cell to be very different in character and concentration, and upon this condition the integrity of the living cell undoubtedly very largely depends. We find in fact that when the cell dies many substances, confined during life within its interior, diffuse out into the surroundings; the plasma membrane loses its osmotic properties; the plant loses turgor, wilts and withers; analogous changes occur in animal cells, the colloids coagulate and the cell disintegrates. Conversely if we alter the plasma membranes by chemical substances (poisons), so as irreversibly to destroy their semi-permeability, death inevitably follows. Semipermeability is thus for many if not for all cells an essential condition of continued life.

Semipermeability also forms the condition of another fundamentally important property of the living cell, namely, its possession of highly characteristic electrical properties. Physical chemists find in general that if a solid film or other partition consisting of any sufficiently impermeable material—*e. g.*, glass, an organic membrane or a precipitation membrane of copper ferrocyanide or similar material—is interposed between two different solutions containing electrolytes which are thus prevented from mixing, a permanent difference of electrical potential arises between the two solutions. The same appears also to be true of the protoplasmic surface-films or membranes. Apparently, so long as the plasma membrane preserves its normal semi-permeability there exists a considerable difference of electrical potential between its external and internal surfaces—*i. e.*, between the exterior and the interior of the cell—dependent on the difference in composition between the protoplasm and its surroundings. Thus the exterior of a resting muscle cell or nerve fibre is always found positive relatively to its interior. But with the loss of semipermeability at death this potential difference—or demarcation-current potential—also disappears. It thus evidently depends upon the semipermeability of the plasma membrane; and since this electrically polarized condition of the membrane is undoubtedly a factor of prime importance in many cell activities, including stimulation, we see again how physiologically essential a property this semipermeability of the plasma membrane may be.[2]

Further, there is little doubt that this property is one of the essential conditions on which the possibility of stimulation depends. Nernst has shown that an electric current stimulates by changing the concentration of ions at the semipermeable membranes of the irritable tissue; this is equivalent to producing a potential-difference or electrical polarization between the outer and inner surfaces of the membrane. The normal preexisting or physiological potential difference is thus altered—in stimulation is typically diminished—and when this change is sufficiently extensive and rapid the tissue gives its characteristic response. Now these polarization-effects depend on semipermeability, since if the membrane allowed all ions to pass freely the differences of concentration in which the polarization depends evidently could not arise. We find in fact that the cell whose membranes have lost their semipermeability does not respond to stimulation. Such a cell is "dead"; this however need not mean that all vital manifestations have ceased; many metabolic processes may in fact continue in dead cells and lead to far-reaching chemical transformation of the cell-constituents; such changes are called "autolytic." What is lost is the power of responding to stimulation; hence the automatic regulation of the vital processes ceases, and presently these

[2] *Cf.* my article on the rôle of membranes in cell processes in THE POPULAR SCIENCE MONTHLY for February, 1913.

come to an end. We have seen that such a cell has also lost the characteristic vital potential difference between exterior and interior. Response to stimulation thus depends on semipermeability, which implies polarizability of the membranes bounding the irritable cells or elements. This conclusion is one of far-reaching importance, because it localizes the primary change in electrical and hence in other forms of stimulation at the plasma membranes. Some *membrane-process* forms the first stage of the response to stimulation. The membrane is thus not to be regarded as a mere passive diffusion-preventing barrier between living substance and surroundings, but as the essentially sensitive and controlling portion of the cell.

Although there is much evidence that the initial event in stimulation is a surface-process and involves a change in the chemical and physical properties of the plasma membrane, the precise nature of this change is imperfectly understood at present. It seems, however, clear that it involves a temporary loss or lowering of semipermeability: *i. e.*, the osmotic properties of the membrane are altered, and along with these its state of electrical polarization. This change forms the condition of the other and more complex changes in the interior of the stimulated cell. Evidence of a temporary loss of semipermeability comes from a number of sides, and is seen in the irritable tissues of both animals and plants. Many motor mechanisms in plants depend on this change; *e. g.*, the movements of the sensitive plant, of the Venus' fly-trap, the tentacles of the sundew, etc. Turgid cells arranged in special ways lose their turgor on stimulation and collapse; the resulting movements may be so rapid—*e. g.*, in the Venus' fly-trap—as to simulate muscular contraction. Yet the effect is undoubtedly due to a loss of water caused by a change in the osmotic properties of the plasma membranes.[3] Phenomena of just this kind are not seen in animal cells, where osmotic distension or turgor plays a less important part than in plants; but in gland-cells, many of which are under nervous control, closely similar changes follow upon stimulation. Water and dissolved substances are rapidly lost from the cells, which in many cases shrink at the same time. Electrical variations accompany these processes in both the plant and the animal, and are probably directly due to the change in the membranes. An especially clear parallelism between increase of membrane-permeability and stimulation as seen in the larvæ of the marine annelid Arenicola; these larvæ are minute worm-like organisms a third of a millimeter long, actively muscular, and swimming freely by their cilia. When brought into pure sodium chloride or other appropriate salt solution the muscles instantly contract strongly and the contraction is invariably accompanied by a

[3] The term plasma membrane is applied by some botanists to the entire layer of protoplasm between cell-surface and vacuole-surface. The most external surface-layer, to which ordinarily the term is applied, can not in fact be sharply separated from the inner protoplasm.

rapid loss of a yellow coloring matter from certain cells forming part of the body. Apparently any change of condition, chemical or other, that increases the permeability of these cells sufficiently to cause a rapid loss of pigment causes also strong stimulation of the irritable elements. It is possible to prevent the stimulating effect of the salt solution by anesthetics or by certain other salts, *e. g.*, calcium or magnesium chloride; and at the same time the change in the pigment-containing cells is also prevented. Rapid increase of permeability and strong stimulation thus show a definite parallelism. Other widespread phenomena, such as the refractory or inexcitable period shown by all irritable tissues immediately after stimulation, point in the same direction. There is indeed an unusually broad basis of biological fact for the inference that in irritable tissues the plasma membranes undergo a sudden and well-marked increase of permeability during stimulation—*i. e.*, lose their semipermeability for a brief time, the exact duration of which varies characteristically for different tissues.

Stimulation appears always to be accompanied by a change in the electrical properties of the irritable elements; and there is every indication that the characteristic negative variation or action current is an expression or consequence of the above change in the membranes. As already pointed out, any semipermeable partition or membrane separating two electrolyte solutions becomes the seat of an electrical polarization, whose degree depends on the nature and concentration of the dissolved substances and on the nature of the partition. Under these conditions any sudden increase of permeability—sufficient to abolish semipermeability—must have the same effect as if the partition were suddenly to disappear; the potential difference between the two solutions then falls to what it would be if no partition separated them. The variation in the electrical potential of the cell-surface during stimulation has in fact the characteristics that we should expect to find if just this change occurs. The electrical variation is always in the direction of an increased *negativity* of the stimulated region; similarly the dead or injured region where the membranes have lost their normal properties always becomes negative, only permanently instead of transitorily so. In stimulation the membrane-change is reversible, in death irreversible. But the *direction* of the transitory electrical variation of stimulation indicates a temporary change in the osmotic properties of the membranes of the same general nature as that associated with death or permanent injury.

We conclude therefore that during stimulation there occurs a temporary and well-marked increase in the permeability of the limiting membranes or protoplasmic surface-films; with this change is associated an electrical depolarization. Experiments with the class of substances known as anesthetics confirms this point of view. When present in the proper proportions these substances render an irritable tissue irresponsive to stimulation. I have recently found that they also change the properties of the plasma membranes in Arenicola larvæ and sea-urchin eggs in such a way as to make them more resistant to increase of permeability under the influence of salt-solutions. A definite parallelism appears to exist; if we render the membranes more resistant to alteration than formerly, we render the tissue less irritable. This influence of anesthetics on plasma-membranes is a very general if not universal characteristic of living organisms. Thus the permeability of plant-cells to salts is decreased by these substances, as Lepeschkin and Osterhout have found, and Loewe has recently shown that artificial lipoid-impregnated membranes are similarly affected. These facts explain why anesthetics counteract the effects of stimulating agencies—which cause temporary *increase* of permeability; and since most anesthetics are lipoid-solvents, we are led to the conclusion that they cause their effects by changing the state of the lipoid components of the membrane; thus the properties of this structure are altered—particularly the readiness with which its permeability is changed by external conditions acting upon it.

Irritability would thus appear to depend on a peculiar state of the plasma membranes—one in which under slight variations of external conditions these structures undergo automatically a rapid and pronounced increase of permeability. A certain state of physico-chemical instability or lability of the protoplasmic surface-film seems to be the essential condition on which a highly developed irritability depends. Such a membrane appears to retain its properties unaltered only if the external and internal conditions remain approximately constant, *especially the state of electrical polarization.* If this latter is suddenly changed, as by an external even slight electrical disturbance, some hindrance to interaction seems to be removed, and a chemical process is initiated which instantly alters the character of the membrane and stimulation follows. This, or something closely similar, appears to be the condition in tissues whose irritability is sensitive and rate of response rapid. Apparently all variations occur in the rate at which this change takes place. The electrical variation, whose rate of appearance and subsidence is an index of the rate of the surface-change, is highly rapid in some tissues and slow in others. Thus it lasts for about a thousandth of a second in a frog's motor nerve, and for several seconds in a slowly responding tissue like smooth muscle; and all intermediate conditions are known to exist. These variations in the speed and sensitivity of the response depend primarily on the specific peculiarities of the plasma membranes of the different tissues. What determines the differences between different irritable tissues and organisms in these respects is a subject for future investigation.

These peculiarities of the plasma membranes enable us to understand why the same tissue may respond in the same way to so many different stimulating agencies. Any agency that alters the surface-film to a degree and at a rate sufficient to cause a critical change in its electrical polarization will stimulate. The membrane may be directly altered by mechanical agencies, or by heat or the direct action of chemical substances; or it may contain photosensitive substances and hence be sensitive to light, or special chemical substances and show a specific chemical sensitivity. Whatever alters it in such a way as to change, even momentarily and locally, its permeability and electrical polarization to the critical degree may thus stimulate, *i. e.*, may originate a depolarization which spreads and affects the entire cell. The response which then follows is independent of the nature of the stimulating agency and is determined by special peculiarities of the irritable tissue itself.

The processes which take place in the interior of the stimulated cell are too various and complicated to be considered here. Their nature depends entirely on the specific peculiarities of the cell, and any general characterization is impossible. Usually there is an increase of oxidations and hence of heat-production—in addition to the special physiological manifestation which is evoked—but this is not always the case; thus in nerve, although there is increased loss of carbon dioxide, the heat produced during activity is almost inappreciable; and in other cases there may be a decrease or even complete cessation of all outward activities, *e. g.*, in structures that give an inhibitory response to stimulation; such an instance is seen in the swimming plates of ctenophores which stop movement instantly on slight mechanical stimulation. Facts like these again illustrate the extreme diversity which the entire sequence of events forming the response may show in different irritable tissues, in spite of the essential uniformity of the first stage of the process. This uniformity is the most remarkable feature of physiological stimulation. Nature has apparently found in the variations of permeability and of electrical polarization which external changes may cause in the protoplasmic surface-films the most effective and reliable means of which the internal processes of the protoplasmic system can be made to vary in response to variations in the environment; and in the course of evolution this mechanism has acquired a degree of perfection that still largely baffles physiological analysis.

# THE PSYCHOLOGY OF RELAXATION

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THE gospel of relaxation has been eloquently preached to us by Professor James, Annie Payson Call and others. We have been told that we live under too much stress and tension, that we are too intense and carry too much expression in our faces, that we must relax, let go, unburden ourselves of many useless contractions.

There seems to be a good deal of truth in this. Some of us manage to escape neurasthenia, but few of us are free from fatigue, chronic or acute. We hear with amazement now and again some one say "I was never tired in my life." Surely under normal conditions we ought not to be so tired as we are, nor tired so often.

Under these circumstances a new interest has suddenly awakened in relaxation. The psychology of it is yet unwritten; the physiology of it is obscure; yet the need of it has become apparent. This need has lately been greatly emphasized by an outbreak of recreation crazes of which the dancing craze and the moving-picture craze are the most conspicuous. They have become so general and are so compelling that they even remind us of the epidemics of the middle ages. The almost obsessional character of these crazes may not be wholly explicable on psychological grounds, but it suggests the need of psychological inquiry into the nature of relaxation in itself and into the peculiar conditions of our times which issue, on the one hand, in the outburst of recreation crazes, and, on the other, in a rather wide-spread disposition to fatigue or even nervous disorders.

Meanwhile practical common sense, not waiting upon theory, has turned to discover means for relieving the excessive tension incident to our present habits of living. Some, as we have said, preach the gospel of relaxation, content to tell us that we are too intense. Others have established schools with practical and helpful rules and methods for relaxation and have brought comfort and relief to many. Again, a new and unique interest has suddenly arisen in *play*. Men and animals have always played—but now we have first become conscious of play and curious about it. We insist on play. If children do not play, we teach them to play.

Finally a score of movements, perhaps many score, have sprung into notice, whose purpose is to encourage or provide some form of relaxation. We recall the recreation movement; the physical-culture movement; the playground movement; the Boy Scouts; the Camp Fire girls; the ever increasing interest in athletics, not only in our colleges, but also in our high schools and grammar schools; the radical change in

Young Men's Christian Associations from devotional to hygienic and athletic religion; the renaissance of the gymnasium and the Olympic games; the increased interest in outdoor life of all kinds; the renewed devotion to outdoor games, like tennis, golf, baseball and football; the rapid extension of the play motive into almost every branch of education; the new vacation schools and school excursions; finally the supervised playgrounds, supervised folk dancing, supervised swimming, wading, tramping, gardening, singing and story telling. Even with very young children the Montessori system seeks to relieve the tension of the old task methods by making the child's activities natural and interesting as well as useful.

More than twenty-four hundred regularly supervised playgrounds and recreation centers were maintained last year in 342 cities in this country. A brand new profession has appeared, that of play leaders, employing 6,318 professional workers.

The legislatures of some states have passed laws requiring every city of a certain size to vote on the proposition of maintaining playgrounds. New York City expended more than $15,000,000 on playgrounds previous to 1908. The city paid $1,811,000 for one playground having about three acres. Chicago spent $11,000,000 on playgrounds and field houses in two years. Formerly the boy could play on the street, in the back alley, in the back yard; now the alley and back yard have disappeared, the street is crowded with automobiles and the few remaining open spaces are given over to the lawn mower and keep-off-the-grass signs, while more and more the school has encroached on the boy's precious period of growth, filling nine of the twelve months of the year and carrying the dreaded examination even into his evenings.

For reasons which will be shown presently boys *must* play. Take away the opportunity for legitimate play, and the play instinct, the instinct of rivalry, of adventure, of initiation, will manifest itself in antisocial ways. Hence the juvenile court and the reform school. "Better playgrounds without schools," says one writer, "than schools without playgrounds."

Our purpose, however, in this article is not to consider the practical and sociological aspects of play, important and interesting as they are, but rather its psychological aspects, the object being to determine if possible what play is and why it is necessary. We shall have in view not children's play merely, but play in its wider sense and especially the play and sport of adults.

Herbert Spencer was the first writer to propose a theory of play. Spencer's theory, which came perhaps from a suggestion of the poet Schiller, was that play is due to the overflow of energy, superabundant energy. It expends itself, therefore, in activities having no further end than the activities themselves, while work is due to the attainment of some end.

In so far as the Spencer theory emphasizes the spontaneous character of play as compared with work, it is illuminating. And if by superabounding energy Spencer means nothing more than a condition of vital health of which play is the spontaneous expression, his theory is helpful and true. But the impression that one gets from this theory is that quiescence is considered to be the natural condition of the child and that when energy superabounds then he plays. Thus far the theory needs a radical revision. Still more, the Spencer theory makes no attempt to explain the *forms* of children's play and of adults' sport, nor their historical significance.

The next theory of play was that of Karl Groos, developed in his two books "The Play of Animals" and "The Play of Man." It is called the "practise and preparation theory" and maintains that play is an *instinct* whose purpose, during the long period of immaturity, is to perfect through play the activities afterward required in serious life. For instance, the girl jumping rope doesn't know why she is doing it except that it is fun. But really it is an instinct whose purpose is to develop certain essential muscles.

This theory is less illuminating than that of Spencer. All the activities of children are in a sense a preparation for life, but the form taken by children's play is not the form of their future activities, except in a comparatively few of the imitative plays. As we shall see presently, the Groos theory does not apply to the characteristic and most deeply fascinating plays of childhood and youth. Without denying the truth that play is a preparation for life, a wholly different principle will be found to determine the form which the plays take. Groos has more recently supplemented his views by a "Katharsis" theory of play already suggested by American psychologists.

A third theory of play has connected the plays of children with the serious pursuits of primitive man. A mass of facts showing this connection has been collected by Stanley Hall and his school—facts which no future writer on the theory of play can ignore. The manner of this connection and the reason for it have not been clearly shown. Sometimes it has been included under the so-called law of recapitulation, a theory to which critical reference will be made below. For the moment, however, it will be sufficient to mention some instances of this striking resemblance between the habits of our human ancestors and the plays of children, calling attention to the fact that the resemblances extend not only to the plays of children, but also to the sports of men.

Haddon and Tylor have studied the history of the kite and the top and of marbles and have shown their very ancient character and their connection with early religious and divinatory rites. The same may be said of casting lots, throwing dice, games of forfeits and games with common playing cards. The mental habits of our ancestors, as we know, survive in the counting out rhymes, in the charms and talismans and superstitions of children. One recalls the magic formula used by Tom Sawyer for driving away warts.

> You got to go by yourself in the middle of the woods where you know there is a spunkwater stump, and just as it's midnight you back up against the stump and jam your hand in and say:
>
> Barley corn, barley corn, injun meal shorts,
> Spunkwater, spunkwater, swaller these warts
>
> and then walk away quick eleven steps, with your eyes shut and then turn around three times and walk home without speaking to any one, because if you speak, the charm's busted.

The mental habits of the child seem like echoes from the remote past, recalling the life of the cave, the forest and the stream. The instinct exhibited in infancy, as well as in boyhood, to climb stairs, ladders, trees, lamp-posts, anything, reminds us of forest life; the hide-and-seek games which appeal so powerfully even to the youngest children recall the cave life of our ancestors, or at least some mode of existence in which concealment from enemies, whether human or animal, was the condition of survival; while the instinct of infants to gravitate toward the nearest pond or puddle, the wading, swimming, fishing, boating proclivities of every youngster, seem like a reminiscence of some time when our fathers lived near and by means of the water.

During a long period in the evolution of life among the higher animals and in the early history of man, the one all-important factor was *speed,* for upon it depended safety in flight from enemies and capture in pursuit. This ancient trait has persisted and survives to-day in a deep instinctive joy in speed, whether exhibited in running or coasting or skating or in the speed mania which lends such delight to motoring, flying, fast sailing and fast riding.

Again, the ancient life of pursuit and capture persists upon every playground in the familiar games of tag, blackman, pull-away, and a hundred others. Indeed, for the exhibition of this instinct, no organized game is necessary. Sudden playful pursuit and flight are seen wherever children are assembled. The ancient life of personal combat is mirrored in the plays of children in mimic fighting and wrestling. The passion of every boy for the bow and arrow, sling, sling-shot, gun or anything that will shoot, is merely the persistence of deep-rooted race habits, formed during ages of subsistence by these means.[1]

There was a time when man lived in close relation with and dependence upon wild and domestic animals. This period is reflected in many forms in the child's life, in his animal books, his animal toys, his teddy bears, in his numerous animal plays. The former dependence of man

[1] Comp. "The Psychology of Football," by present author, *Amer. Jour. Psych.*, Vol. XIV., pp. 104–117. A few paragraphs from this article have been repeated in the present one.

upon the horse is shown in the instinct of the child of to-day to play horse, to ride a rocking-horse or a stick or anything. The child's first musical instruments, the rattle, the drum and the horn, were the first musical instruments of primitive man. These illustrations could be multiplied indefinitely. They show the limitations of the Groos theory of play, for none of the plays of this class have much to do in preparing the child for the life of to-day, or in giving him special practise for his future work. We ourselves are so much slaves of the past in our habits of thought that we do not easily realize how far from the actual life of the present day is this play-life of the child. The real world of to-day is that of the laboratory, the school, the library, the bank, the office, the shop, the street, the factory, the farm and the railroad. Notwithstanding the child's strong imitative bent, his world, as shown in his tales, his dreams and the plays he loves best, is that of the forest, the stream, the camp, the cave, the hunting-ground and the battlefield.

Everything which has such a vital and absorbing interest for the boy has had at one time in our racial history an actual life and death interest for mankind. Take, for instance, the jackknife. How many knives has your boy had and lost and what rich joy there is in every new one! We see how the practise and preparation theory of play fails here. The knife has no significance in society now. It has degenerated to mere finger-nail purposes. But at one time it meant life in defence and food in offence. Your boy's supreme interest in the knife is a latent memory of those ancient days. Those who could use the knife and use it well, survived and transmitted this trait to their offspring. The same could be said of the sling, the bow and arrow, and of sports like boxing, fencing, fishing, etc.

Consider the fascination of fishing. This is not a practise and preparation for the real life of to-day, but a reverberation of racial activities. In a summer resort where the writer was a visitor the past summer, day after day the whole male population of the hotel resorted to the fishing grounds. They paid two dollars and a half a day for a guide, seven dollars a day for a motor-boat and a cent and a half apiece for worms. Surely a stranger uninitiated into our habits of thought would have been amazed to see these returning fishermen at night indifferently handing over their catch to the guide. It was the fishing they desired, not the fish, and yet great was their woe when one large fish was lost in the act of landing. It is estimated by the *New York Times* that on Sundays and holidays when the weather is fine, 25,000 people in New York City go fishing at a minimum cost of one dollar each, and of these no doubt more than 95 per cent. go for fun and not for the fish. At some stage in the history of human development fishing was without doubt a general means of subsistence. Those who could catch fish survived and handed down this instinct. Likewise the fascination of gathering wild nuts and berries is out of all proportion to the value of them when gathered. But nuts and berries were once of vital concern to our fathers.

It is in baseball and football, however, that we best see the historical significance of play. The daily paper is a good index of popular interest. Here we shall often find perhaps seven, perhaps twenty columns devoted to baseball, while no other single subject whether in politics, art, literature or science, aspires to two columns. How shall we explain the absorbing interest in baseball and football as well as in horse-racing and prize-fighting?

In baseball we have a game combining three of the most deep-seated racial instincts, the instinct to throw, to run and to strike. During untold periods of the life history of our race, survival has come to him who could throw the straightest, run the swiftest and strike the hardest. To throw something at something is almost as natural for a boy as to breathe. Throwing, batting, running are no longer of any service in this age of mind, but they were the conditions of survival in the distant past. Baseball reinstates those ancient attitudes and brings a thrill of cherished memories. Any one who has ever held a bat in hand and assumed the expectant attitude of the batter knows the peculiar thrill which is explained only by recalling that his distant ancestors in just that attitude beat down with a real club many an opposing foe, whether man or beast, and those who held clubs in this position and struck hard and quickly survived and transmitted this instinct. Dr. Gulick says:

> Baseball is a complex of elements all of which date back certainly to our prehuman ancestors. The ability to throw a stone with accuracy and speed was at one time a basal factor in the struggle for survival. The early man who could seize a bough of a tree and strike with accuracy and great power was better fitted to survive in the brutal struggles of those early days than the man not so endowed. He could defend his family better, he was better fitted for killing game, he was better fitted for overcoming his enemies. The ability to run and dodge with speed and endurance was also a basal factor.[1]

The instinct to throw, as the same author shows, belongs to boys only, scarcely appearing in the case of girls. The awkward throw of girls, like the left arm throw of boys, is well-known. The plays of girls reveal their own set of instincts recalling the habits of primitive woman. "We are the descendants of those men who could throw and those women who loved children."

Football excites still greater enthusiasm than baseball because it reinstates still more primitive forms of activity, for instance the face to face opposition of two hostile forces, the rude physical shock of the heavy opposing teams, the scrimmage-like, mêlée character of the collision, the tackling and dodging and the lively chases for goal, as for cover. The spectators at a great football game go wild and behave like children,

[2] Interest in Relation to Muscular Exercise,'' by Luther Gulick, M.D., *American Phys. Ed. Rev.*, Vol. VII., 2.

shouting, gesticulating and throwing their hats into the air, because before them is enacted again the ancient, familiar scene.

Success in modern life does not depend upon swiftness of foot or swiftness of horse, yet our sports take the form of foot races and horse races. There was a time when swiftness of foot and swiftness of horse were vital. So in our sports these old scenes are reenacted. Few of us can read a vivid account of a horse race or chariot race without profound emotional disturbance, out of all proportion to the actual significance of these things in the life of to-day. In fact they have no significance whatever now. They belong to the past. So it is of hurdle jumping, hammer throwing, shot putting, trapeze performing, and all the events of the circus ring, the athletic track, the stadium or arena. They reenact ancient scenes and old forms of racial activity. The boy swinging on a trapeze or hanging by his toes from the limb of a tree is not practising the things he will have to do in later life, and this activity is of no value to him as "a practise and preparation for life," except so far as any physical activity contributes to his bodily development. A boy must be active, and activity is essential to his development, but the form of his activity is to a great extent determined anthropologically and his delight in it is directly proportional not to its future usefulness, but to its historic truthfulness.

The sports of the ancient Romans illustrate, just as ours do, this character of play. There is authority for the statement that 385,000 spectators were present in the Circus Maximus at one time.[3] The spectacle that fascinated them was the age-old spectacle of man fighting with man in deadly combat, and man with beast, and beast with beast.

Such, then, are some of the facts illustrating the curious resemblance between the habits and pursuits of early man, on the one hand, and the plays of children and the sports of men, on the other. Is it possible to explain this resemblance and arrive at a satisfactory theory of play? An attempt has been made to show a kind of parallelism between the mental development of the child and the historical development of man and to include this parallelism under the so-called biological law of recapitulation. But this theory, sometimes called the recapitulation theory, encounters no less difficulties than the Spencer theory or the Groos theory. Even if the law of recapitulation were generally accepted by biologists, it would not explain the plays of children to refer them to it. There would still be only a resemblance—or at the most a parallelism. But more serious difficulties arise. This theory makes no attempt to explain the sports of adults and it is becoming increasingly evident that the plays of children and of men are to be explained on the same principle.

3 Some manuscripts of the Notitia give the number as 485,000. Some modern critics believe that the actual seating capacity of the Circus was only about 200,000 at its greatest enlargement. Great crowds, however, witnessed the events from the surrounding hills and houses.

If it could be shown that the child passes through the various stages of development that the race passed through, this would throw no light on the sports of men.

Nor again does this theory explain the delight which children take in their play nor does it make clear the distinction between work and play. Why does a boy become so quickly fatigued hoeing in the garden or raking leaves when his physical endurance is beyond belief when hunting, fishing or playing football? It is commonly assumed that in the former case the fatigue is fictitious, but this is not the case, as the results of forced child labor always show.

Finally this theory admits of no clear educational application. All the writers of this school assume that since the child's plays tend progressively to take the forms of the serious pursuits of his ancestors, therefore these tendencies should be encouraged. Every child, they say, must live out and live through these stages in order that he may enter into the next stage sound of body and mind. This may be true, but no satisfactory reason for it has been given. Why rather should not these survivals of savagery be discouraged and the boy's plays be modeled after his future manly duties?

Failing thus to find the recapitulation theory of play any more satisfactory than the other theories, but recognizing the full value of the facts from which it sprang, let us see whether these facts are not susceptible of a somewhat different interpretation.

It is evident that progress in civilization has depended upon the development of certain peculiar forms of mental activity which were relatively undeveloped in primitive man. If it be true that these forms of mental activity are relatively undeveloped in the child and when developed in the adult are most susceptible to fatigue, we have at once the key to the whole problem of sport and play, explaining why the plays of children and the sports of men take the form of primitive human activities.

It is not necessary for our present purpose to attempt any exact description of those forms of mental activity which are newest in human evolution. Commonly they are exhibited as a constantly increasing power of inhibition and a constantly increasing capacity for sustained attention, and they depend no doubt upon that growing complexity of brain structure which makes possible and easy new forms of association. The individual becomes able therefore to hold steadily in view the image of a desired end, to inhibit the old and habitual responses which are no longer appropriate to that end, to analyze a given situation in thought so that the response may be to certain elements in the situation rather than to the situation as a whole, and thus to meet a given situation with a new response.

Even in the lower forms of animal life this tendency appears as the persistent striving of the organism toward an end, that end being usually some changed relation which shall subserve the life purposes of the individual. This striving has for its subjective correlate a state which we may characterize as tension, strain, stress or effort. It is this aspect of human behavior that constitutes work and distinguishes it from play. It is the power to hold oneself to a given task for the sake of a given end, to carry on an occupation even though it may have ceased to be interesting for the sake of some end to be gained other than the activity itself. This is work and it involves stress, strain, tension, effort, endeavor, concentration, application and inhibition, and is unconditionally the ground of progress. It is precisely the lack of this capacity for sustained and persevering effort that characterizes all uncivilized races.

Play is just the opposite and includes all activities in which the stress and strain are absent. Play is self-developing and supplies its own incentive. It is spontaneous and pleasant because of the sense of ease which accompanies it. Clearly play in this sense is something broader and more inclusive than those activities which we usually embrace under the term. It includes not merely children's plays and grown-ups' sports, not only hunting, fishing, boating, yachting, motoring, flying and all kinds of outing, not merely games and races and spectacles and tournaments and fairs and expositions, but also the theater and the opera, the enjoyment of music and painting and poetry, our daily paper and our magazines and our novels and our romances, and for that matter, many forms of so-called work in which the interest is self-developing, such, for instance, as gardening for pleasure. Relaxation or recreation would be perhaps more fitting terms to designate this large class of human activities.

All the evidence that we have points to the validity of the law that those peculiar forms of mental activity which have developed late in the evolution of man are most affected by fatigue—a law fully sustained by the study of psychasthenics and their incapacity for higher mental operations, as well as by the observation of people normally fatigued, while it is known that the disintegration of the nervous system in disease follows the reverse order of its development.

The application to the explanation of adult sport is evident. Those forms of mental activity which are developed late in the history of the race, and late in the life of the child, that tense and strenuous activity upon which modern progress depends, the power to hold ourselves by sustained attention and sustained effort down to hard and uninteresting tasks for the sake of some ultimate end, the concentration of the mental forces upon problems of science, philosophy and invention, and the inhibition of old and undesirable responses—all these bring quick and extreme fatigue and demand rest for the corresponding parts or centers of the brain. In sleep these higher mental processes enjoy almost complete suspension. But the exercise of these powers during the long hours of our waking day would result in speedy collapse. It is clear therefore that our daily activity must be made up quite largely of responses of the simpler type, which shall give exercise to our muscles and sense organs and invoke older and more elementary forms of psychosis, and at the same time allow the higher ones to rest. Such is relaxation in all its forms and of such consists almost wholly the life of the child. For the brain centers associated with the above-mentioned forms of mental activity are undeveloped in the child as they are in primitive man, so that we may say with considerable truth not that the child *ought not* to work, but that he *can not* work.

So we understand why adult sport resembles the activities of primitive man. The older, the more basal, the more primitive, so to speak, the brain centers used in our hours of relaxation, the more complete our rest and enjoyment. Just in proportion as the sport is primitive, so much greater is the sweet peace which it seems to bring to the troubled soul, simply because it involves more primitive brain tracts and affords greater release from the strenuous life. So while we find one hundred and fifty spectators at an inter-collegiate debate, we find a thousand at an automobile race, five thousand at a horse-race, twenty thousand at a great baseball game, fifty thousand at a great football game and 385,000 at a gladiatorial show. The nervous tracts which function in such activities as hunting and fishing and swimming and boating and camping and in football and baseball and golf and polo, in horse-racing and bull-fighting, are deep worn, pervious and easy. During countless centuries the nerve currents have flowed through these channels. Witnessing these rude contests, pictures of former ages, or taking part in these deep-seated, instinctive actions brings sweet rest and refreshment. "The racially old is seized by the individual with ease and joy."

The game of golf has a peculiar restorative power surpassing all medical or other therapeutic arts. We may be physically and mentally weary from a morning's work. Despite the strenuous physical exertion of an afternoon at golf, our fatigue is lessened, not increased. Fresh air does not explain it. It is a return to the primitive outdoor life. We stride over hill and through ravine; we stumble into ditches; we carry a club and strike viciously at the ball; we follow the ball with the eye and search for it in the grass as our forefathers searched for their arrows and missiles; we use our legs and our arms; we let the nerve currents course through the more ancient channels; we revel unconsciously in latent memories and old race habits and come back to our work rested, renewed and refreshed.

But you may say golf and bowling and baseball and prize-fighting require skill and close attention and tax mind as well as muscle. But this is not the point. Our primitive ancestors had skill. To see quickly and correlate nicely eye and hand or eye and foot was an early acquisition. It is not this that fatigues us in modern life. It is the everlasting, high-pressure grind. It is the holding ourselves down to hard working and hard thinking and long-sustained tasks. It is analysis, concentration, effort, dead lift of mind, the kind of psychosis that digs Panama canals, perfects automobiles and airships, discovers new laws of mind and matter in the laboratory, thinks out new fields for the investment of capital, scrutinizes countless court records for precedents in law which may clear our clients, holds the ship's captain on the bridge in times of peril, keeps the soldier at his post and the clerk at his desk through the long hours and the weary days. As the strenuous life increases in city and country, there is an increased demand for relaxation, whether in the form of baseball or football, horse-racing or gambling, or in the form of the automobile craze or the auction-bridge craze or the moving-picture craze or the tango-dancing craze. These are all methods of escape from the clutch of the modern strenuous life, exhibited in all countries, but most noticeably in America, for whatever it is that is driving the human race forward in the path of progress so rapidly and relentlessly, seems to have gripped the Anglo-Saxon people particularly hard.

Even these many forms of relaxation are not sufficient to relieve the overwrought brain centers, and so in ever-increasing amounts we have recourse to artificial means of relaxation through narcotics, such as alcohol, tobacco and other drugs. Alcohol by its slight paralysis of the higher and later developed brain centers, accomplishes artificially what is effected naturally by play and sport, that is, it liberates the older, freer life of the emotions and the more primitive impulses.

Thus from our new point of view the difficulties in regard to children's play disappear. The reason why children play and why their plays take reversionary forms is now evident. The higher brain centers, those making work possible, are not developed. If a child does *anything,* he must play, *i. e.,* his activity must take the form prescribed by the brain centers already developed, and these are the old racial tracts. He is equipped with a nervous mechanism adequate for old racial activities and for the most part with these only. The little girl hugging and nursing her doll is not the victim of an instinct whose purpose is to prepare her for later maternal duties. She is simply doing what her mother and her grandmothers have done since the foundation of the world. If they had not done so, she would never have been born.

The child does not play because of surplus energy, for under normal conditions *all* his energy is expended in play; the child is a playing animal. Nor does he play because of an instinctive need of practise and preparation for life's serious duties, for the form of the latter is constantly changing while the plays of children remain much the same from year to year and century to century. Nor finally does he play because it is necessary for his complete growth that he should pass through the several stages of racial history. He plays because he is a child and to the child's natural and active life we give the name play to distinguish it from the life of conscious self-direction, of strain and effort and inhibition which evolution has imposed upon the adult human being.

When we say that all of the child's activity takes the form of play, the statement should be regarded as a general one and as such it is true. As the term play is actually used there are certain minor classes of responses which are not included. The child's instinctive shrinking from a large furry animal is as much a part of his original nature as his tendency to run and jump and climb and wade. His responses in the taking of food, likewise, and in protecting himself by crying are original inherited responses. But to crying and sucking and shrinking from objects of fear we do not give the name play, because, being of the immediate life-serving kind, they bear a closer resemblance to those responses to which in later life we give the name work, and we reserve the term play for that larger and characteristic class of activities which are distinguished from the conscious self-directive life of the man. The play reactions of children therefore belong to their original nature. They are instinctive. Social heredity may account for the forms of organization of many of the plays of children as well as the *sham* character which they assume when compared with their originally serious form, but the *elements* of the great mass of the plays which are dearest to the hearts of children are truly instinctive.[4]

Possibly the objection may be made that in this account of children's play, our attention has been directed too much to the plays of boys and that the plays of girls have been disregarded. An important distinction arises here to which in this present writing only passing reference can be made. The life of stress and effort and self-direction of which play is the antithesis is essentially masculine. Man represents the centrifugal motive; he stands for movement, change, variety, adaptation; for activity, tension and effort. Woman represents the centripetal motive; she stands for passivity, permanence, stability, repose, relaxation, rest. She has greater measure and harmony. She has therefore less need of the release afforded by primitive forms of activity. Girls, of course, play and their plays follow the same laws as those of boys, but yet in less marked degree, while adult sports are for the most part masculine sports.

Just at present what we call civilization is tending in the direction of the masculine motive—to variation, adaptation, change—to effort,

[4] Compare James's "Psychology," Vol. II., p. 429, *note.*

stress and work. That it is producing anything remarkable, except in invention and the mechanic arts, is doubtful. The really great things of the world have been produced not with great effort, but with great ease. The magnificent productions of the age of Pericles in architecture, sculpture, painting and literature seem to have been more like the overflowing of a full vessel than like the laborious achievements of hard work. But the present age is the age of great effort, the age of work, and hence our growing demand for more relaxation and rest.

The educational application of this theory of play presents less difficulties than the older theories. It is not necessary that the child should live through and live out any series of savage stages. It is merely necessary that he should be kept active with the mental and physical equipment that he has, that work should not be too early imposed upon him and that his plays should be so organized and supervised that, while retaining the elementary form of his instinctive responses, they may be physically, morally and socially harmless. For instance, a boy, if he is a boy, must throw. It is just a question of whether he shall throw stones at a cat, at a street car, at little children or whether he shall throw a curved ball to the catcher. The latter is harmless, the former dangerous. Again, a boy's instinct of rivalry is very strong. He must do something daring, get ahead of some one, as those of his ancestors who survived did before him. If a proper playground is provided, all these things may be done without injury to society. Otherwise his instinct is expended in an effort "to steal on Casey's beat and get away with it." Again, at a certain age the dancing instinct is developed and the children must now be taught the graceful and healthful folk dances.

In our modern cities supervised play has become necessary for social order, for the reason that the old conditions of spontaneous, healthful play have been taken away. Says Luther Burbank quoted by Geo. E. Johnson:

> Every child should have mud-pies, grasshoppers, water-bugs, tadpoles, frogs, mud turtles, elderberries, wild strawberries, acorns, chestnuts, trees to climb, brooks to wade in, water-lilies, woodchucks, bats, bees, butterflies, various animals to pet, hay fields, pine cones, rocks to roll, sand, snakes, huckleberries and hornets; and any child who has been deprived of these has been deprived of the best part of his education.

As regards adults, the social applications of the theory are equally obvious. There must be large periods of relaxation from the high tension life of to-day. If they are not provided in the form of healthful and harmless sports, there will be irritability, abnormal fatigue and anti-social outbreaks. There will be tango-dancing crazes and auction-bridge crazes and there will be ever-increasing resort to the temporary harmonizing effect of alcohol, tobacco and coffee.

Even in the life of the family the harmonizing influence of games is seen. The friction sometimes exhibited among its members, in some cases taking the extreme form of nagging, wrangling and quarreling, is no doubt due in large part to the fatigue of the higher brain centers. In such cases it will often be found that participation in some simple game, particularly an outdoor game, such as golf, tennis or even quoits, will completely relieve the situation, bringing sympathy, harmony and peace. In society, the larger family, the same effect must follow upon the larger participation in healthful sports. It is sometimes a matter of surprise to us in periods of national prosperity when wages are good and work obtainable, that unrest increases, together with crime and insanity. It may be because the high tension with its consequent fatigue is not relieved. What is needed is less work and worry and more healthful relaxation. Worry is a good example of the high-tension life that is a part of our civilization. Worry is only an excessive form of prevision. It is well enough for preachers to tell us not to worry, but worry is precisely that form of behavior upon which civilization depends, namely, solicitude and care for the future. As a nation we are just beginning to worry, for instance, about the depletion of our forests and soil, and it is well that we are doing so. But sometimes we become excessively solicitous about the future, whether it be about the rent or the winter's supply of coal or our future health or the health and morality of our children, and this is what is usually spoken of as worry. It is very wearing, for the reason that it brings constant strain upon delicate and recently developed brain centers and makes relaxation imperative.

If we have correctly described the theory of play and the psychology of relaxation and their relations to the conditions of our modern life, it will be evident at once that the need will not be supplied merely by providing more playgrounds for children and more holidays and sports for grown-ups, vital as these are. The difficulty goes deeper and calls for emphasis of still other forms of relaxation than play and sport. There are many of these, such, for instance, as music, which is one of the best, and rhythmic dancing, which, being very ancient racially, is a form of relaxation of unsurpassed value. An ever-ready and convenient form of relaxation is the modern novel, in which the attention is sustained objectively as in the chase or the drama, but its value as relaxation is greatly less than in the old and social story telling. Society in all its forms is a healthful means of relaxation. All valuable games and sports are social and the mere mingling with our fellows lowers the mental stress and tension. Primitive man was wholly social and survived only in cooperative groups. The reversionary character of crowd behavior has been made well known to us.

Religion may be mentioned finally as a mode of relaxation of the highest value. Religion is a letting go the stress and tension of the individual and resigning oneself to an outside power, whether that power be God or the church. The function of religion in this aspect is that of a sustainer, and religion loses its usefulness wholly if the individual, as is often the case, feels it his duty to sustain his religion. His religion must sustain him. Clubs, societies, fraternities of all kinds, exercise a similar function. The great charm of all fraternal societies is that they relieve the stress, the burden, the tension of the individual and shift the responsibility upon the society as a whole. The society is back of him, to some extent will do his thinking for him, decide moral questions for him, relieve his worry.

Just as man has physically lifted himself from the earth, overcoming gravity, so mentally he has raised himself above the other animals by the fatiguing exertion of his higher mental powers. The first animals were marine animals. They floated in or upon the water without effort. Then came creeping land animals prone upon the ground but not so completely supported as in the water. Gradually the animal lifted himself upon four legs and at last, by infinite labor, erect upon two, and the tension is correspondingly great. The horse rests very comfortably upon his four legs if allowed to stand and needs to lie down scarcely an hour in the twenty-four. Man sustains himself with constant effort in an erect position and must sit much of the time on a chair and at night reverts to the original position of the worm, prone upon the bed. This illustrates the whole theory of relaxation. It is always some form of reversion to primitive attitudes or primitive psychoses and it brings rest and peace and harmony.

The rhythm of moral and social progress probably follows the same law. Periods of rapid progress are followed by periods of rest and relaxation. From time to time we are shocked by waves of vice and epidemics of immorality. We hear suddenly of conditions of astonishing laxity of morals in the small towns of our western states which are supposed to be models of propriety and we say that the world is going to the bad. But our judgment is too hasty. These things are stages really in progress. What we witness is a kind of moral relaxation, a relapse to more primitive conditions, as a result probably of progress that is too rapid, of tension too great. Something like moral fatigue takes place and a reaction follows.

Just at present we are hearing it said that our country has gone "amusement mad." Well, our manner of life has been very strenuous. The tension has been high. Something was bound to happen. Other forms of relaxation have failed us just when we needed them most—particularly art and religion. We are told that the art of ancient Greece was the product of the Greek genius. Perhaps it was the cause of it. Both art and religion entered intimately into the daily life of the Greeks. They have departed from ours.

# THE NEED FOR A SALARIED MEDICAL PROFESSION

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THE state, in the interest of its own preservation and progress, has assumed control of certain activities closely affecting the life of every citizen. Among these are the care of the public roads, the distribution of the mails and the education of the youth. Still other activities now in private control should be supported by the state for the benefit of the whole people. One of the most important of these and the one perhaps receiving most public attention at the present time is the care of the health of the people, a function now delegated largely to physicians, men who receive their reward for community service in the form of fees from private individuals.

Attention to the public health presents two aspects, the one preventive, intended to preserve health by removing the causes of disease; the other curative, and intended to restore to health those who have fallen ill. The medical profession, through a large part of its history, has been almost exclusively concerned with problems of curing disease. The physician has had no direct financial interest in warding off disease from those who were well, but has dealt only with individuals who were ill. Until recently nothing was done to remove the cause of disease, the attention of the physicians being directed toward the problem of finding means of curing or relieving the pain of the one who had already contracted disease.

This was the logical course for physicians to pursue because it was from the sick individual and not from a well public that he received his pay. Under the present system the physician is prosperous in inverse ratio to the health of the community. The doctor is busiest during those seasons when illness prevails most. Were there no disease there would be no need of physicians. This would be an ideal condition for which the people would be glad, not because of hatred of physicians, but because of love for their own welfare. Since the physician to-day receives his reward from the curative side of medical practise he is not professionally interested in the prevention of disease. The public need is for a medical fraternity paid by the public whose interests will be as much in the prevention of disease as in the cure of it. Were physicians paid by the state, they would not fear the loss of income through working for the interests of the well, while at the same time attending to the ill, because the lessening of illness would not necessarily interfere with their incomes. Further, the greater their success in the prevention of disease the less the labor that would be required in the cure of it.

Under the present system much dissatisfaction exists over the charges made by physicians. The poor patient will get together $200 or $300 for an operation or will be treated by novices free of charge, while the rich man will pay $1,000 for the same service. The physician is bound by the ethics of his profession to heed the call of every individual without any preliminary inquiries as to ability to pay, and must give both prescriptions and medicine to many without hope of reward. He must depend for his livelihood upon the honesty and liberality of those who are able to pay for his services. It also places the burden of caring for the sick poor upon the sick well-to-do, because the physician must make his charges according to the net income desired. The system further tends to develop a class in the community that is looked upon as a pauper group requiring care according to special methods. Out of this condition has risen the system of free dispensaries to which physicians volunteer their services, and to which the poor may go for treatment. The physician prefers to volunteer his services to an institution of this kind rather than have the poor come to his office to interfere with his private practise. Their presence in the office is desired about as much as is the presence of the colored person in the office among white patients. The poor are made to feel the disgrace of their poverty and the well-to-do who frequent the dispensaries are induced to falsify as to their real ability to pay.

The present system is unfair to both the physician and the public. The young practitioner, eager to gain experience, is perhaps rewarded for the voluntary service rendered, but the experienced physician who must devote a certain portion of his time to unremunerative practise is unjustly treated. In certain cases he may derive benefit from the voluntary service in that it may bring him into touch with diseases not usually met with in regular practise. But the general dissatisfaction with the growth of free dispensaries, hospitals, etc., is proof that the medical profession is opposed to both an excessive volunteer service and to a diminished practise. On the other hand, it is unfair to the public because it places upon the poor the stigma of asking for assistance for relief from illness for which he is perhaps not responsible. Prevailing materialistic standards permit the erection of buildings that pure air and bright sunlight never penetrate and that in time become veritable breeding grounds of disease. The poor man, because he is too poor to afford anything better, is forced to live in these dens with every chance that both he and his family will contract serious illness. He goes to the free dispensary and is liable to have his home pried into by some charity visitor or to become known as the recipient of alms. The individual receives the burden that a neglectful society has placed upon him and is stigmatized because he must shift it—too heavy to bear—to the shoulders of other individuals who operate a free dispensary.

The present system prevents adequate and timely aid to those who need it. Many people, even within reach of dispensaries, dread the thought of patronizing them and often waste their earnings in buying nostrums from the neighboring drug store because they are cheap and because they seem to fit their case. Ofttimes they injure themselves more than they help. The pauper, who has lost all sense of deference to public opinion, goes at once to the dispensary and is adequately treated. But the vast multitude, too proud to patronize a dispensary and too poor to patronize a physician, run continual risk of neglecting serious illness.

The preservation of the public health is a matter of too great importance to be entrusted to the care of the person who is ill and who feels too poor to go to the doctor. The sick person becomes a non-producer and a care to his family and friends. If the father becomes ill the family becomes a public charge. If the children contract disease they suffer and die because the poverty of the parent prevents proper medical attendance. The masses of the people are too poor to avoid the risk of letting disease run into the danger period. Conditions demand nothing less than the removal of the stigma attached to dispensary patronage so that any person, be he rich or poor, can go to be treated. Medical attendance should be as free as the public schools. The healthy and well-developed body is as important as the healthy and well-developed mind. The two go together and the one can not be perfect without the other.

If, instead of lessening the amount of free medical attendance it were made universal the present fee system would be limited to the very wealthy and the physician for the common citizen would be placed on a salary basis. This would entail a large increase in public expenditures. Such an increase, however, would be a blessing in disguise in that it would fix public attention on the prevention of disease, thus lessening the amount of suffering in the community by eliminating the causes of it. It would open the way for a great number of people who are now deprived of proper medical oversight to consult a physician before real danger is present. It would eliminate the volunteer work and the charging of the rich to make possible the medical attendance of the poor. The emphasis in medical practise would be shifted from the curing to the prevention of disease. The physicians paid for by the state would become agents in removing the causes of disease. Instead of devoting exclusive attention to the cure of the consumptive or the one afflicted with other ills, contagious or otherwise, they would be concerned with the removal of the causes of the spread of the disease. The public physician would also become the agent for the dissemination of popular information on subjects of hygienic interest. In other words, it would bring the medical profession into line with the highest interests of the social group which they serve and would make the physician in relation to the preservation of public health what he now is in relation to the cure of illness, a leader in the fight for the extermination of disease.

The transition from a fee to a salary system of payment for medical service would not necessarily eliminate private practise. Those wishing the services of a private physician could secure the same at a rate based on value of services actually rendered. The existence of public schools has not eliminated private schools from the educational system. Neither has the public school system resulted in less consecrated service to the public welfare than was rendered by the private school. Neither should a salaried medical profession be less consecrated to its work than one rewarded by fees.

The transition from a private to a public medical practise is gradually coming. The appearance and persistence of free dispensaries and hospitals is not the least evidence of the change. The establishment of departments of health in city and state, the magnificent work of the medical service of the United States government; the system of engaging a company physician adopted by many of the large corporations; the movement toward medical inspection of school children with its accompanying treatment at public charge of children unable to pay for treatment; and the movement toward the public treatment of certain types of disease, such as tuberculosis, all indicate that a new order is coming wherein prevention of disease by trained and paid public servants will be considered as important a matter as the cure of disease already contracted. The economic interests of the medical profession will be brought into line with those of the general public and this is the end which should be sought.

# IS THE MONTESSORI METHOD A FAD?

By FRANK PIERREPONT GRAVES

PROFESSOR OF THE HISTORY OF EDUCATION IN THE UNIVERSITY OF PENNSYLVANIA

AFTER all the popular excitement, spectacular magazine articles, and more or less interesting books on the subject, the busy man—even the educator—is still asking: "What is the Montessori Method?" Is it a wonderful discovery of educational principles, an ingenious invention of material and devices, or merely a new fad that has been exalted by manufacturers of educational apparatus and enterprising journalists into a profitable cult and propaganda? Will the inventor of the "didactic apparatus" be eventually enshrined a little above Pestalozzi and Froebel, Mann and Barnard, in the educational pantheon, or will she be relegated to the limbo of the exponents of tiddledy-winks and ping-pong, of Belgian hares and Teddy bears? While "neither a prophet nor the son of a prophet," it is in the hope of answering such questions and of satisfying such a mild curiosity, that this sketch is added to the pyramid of Montessorian literature.

In the first place, it should be noted that Montessori is on the right track in seeking a scientific basis for her educational structure. Despite the close resemblance of the "didactic apparatus" to the "gift of Froebel," it does not find its justification in German idealism Happily the practise of Montessori, which is so similar to that of the kindergarten, is not handicapped with the necessity of awakening the innate concept of "unity" by "adumbration" in the unsuspecting child through his activities with an ordinary ball. The symbolism, mysticism and obscurantism of the literal Froebelians are replaced by a scientific basis of modern biology, physiology and psychology. Some of Montessori's biological statements have been shown by scientists and physicians to be inadequate, incorrect, or out of date, but, with the rapid expansion of modern science, it is almost inevitable that an educationalist should occasionally reveal a weakness when he builds upon a biological foundation. The scientific attitude of Montessori is an outgrowth of her training and experience. She was the first woman to receive the doctorate in medicine from the University of Rome, and she has followed up this medical education with careful study and researches in psychiatry, experimental psychology, anthropology and pedagogy. And it was her success in supervising the instruction of defective children that led to the experiments that have so stirred the educational world. Her procedure in teaching normal children has fundamentally adhered to the "physiological" method of Seguin, the first great trainer of defectives, and she frankly acknowledges this indebtedness. The scientific foundation of her practise is further shown in the conduct of her schools. Careful records are kept concerning the heredity, parental occupation, feeding and infantile sicknesses of the Montessori pupils, and anthropometric measurements are taken at regular intervals. Moreover, an expert inspection is periodically made of the sanitation and economic conditions in the home of each child.

The Montessori spirit is again revealed in her attitude of allowing the pupil as complete freedom as possible and of holding that the chief function of the teacher should be to study the activities of the child. "The transformation of the school," says she, "must be contemporaneous with the preparation of the teacher. For if we make of the teacher an observer, familiar with the experimental methods, then we must make it possible for her to observe and experiment in the school. The fundamental attitude of scientific pedagogy must be, indeed, the *liberty of the pupil*." In practise, Montessori carries out this fundamental belief more fully than most Froebelians, who also profess it. Instead of holding the children to a fixed and complete order of exercises imposed by the teacher, she maintains that all education worth having is "autoeducation." The children should select their own occupations and solve their own difficulties, and should be allowed to develop themselves both mentally and morally. Only when their activities interfere with the general interest or are useless or dangerous, must they be suppressed. However, while in this latitude toward individual expression Montessori carries out the "following, not prescriptive" education of Froebel more logically than that reformer himself, she does not develop participation in group activities to the same extent as he. Nor is the material used as rich and varied. There is little opportunity afforded for the Froebelian construction and invention, and the development of imagination is ruthlessly nipped in the bud. The interesting plays, songs and stories of the kindergarten find little parallel in the Montessori practise, although at present the founder of the system seems to be expanding these elements. The conception of "autoeducation" is admirable, but it is difficult to see how genuine activities are to be carried on, except within a very narrow scope, unless the material of the Montessorian schools be expanded considerably beyond the confines of the "didactic apparatus."

The most discussed features of the Montessori method fall naturally into three groups. It should be noticed that none of these exercises are absolutely original, but they are sufficiently peculiar to demand consideration in any description of Montessorianism. They are connected with (1) activities of practical life, (2) sense training and (3) the formal studies of the elementary curriculum. (1) When the child first enters the school, even while he is beginning to find himself, he may take part in the activities of practical life. Besides practise in ordinary courtesy, cleaning the room, setting the table, serving a meal, and washing the dishes, the children learn how to button, lace, hook and clasp various articles of dress by means of a unique apparatus. To the opposite sides of light embroidery frames are attached strips of dress material, linen and leather, which are fastened together at the center. Through constant practise with these materials the child learns to dress himself and trains a variety of useful muscular coordinations. Similar exercises in the activities of ordinary life have for some time been a part of the practise of progressive kindergartens and other modern schools. It may well be that Montessori has suggested several new features in this direction, but we must not suppose that the idea is absolutely novel or that we can follow these devices literally without further consideration. There is always danger that the Montessorians, like the Froebelians, may forget that "the letter killeth, but the spirit maketh alive." His more conservative disciples, in their efforts to preserve all the prescriptions of the master, have often forgotten that Froebel's system was adapted to conditions three quarters of a century ago in the simple and peculiar environment of a small German village. Let the Montessorians take warning and elaborate their principles in a practise that will be applicable to the complexities and independence characteristic of the twentieth century in the United States.

(2) The sense training is the feature most stressed by Montessori herself. Even her remarkable achievements in teaching writing seem to have been forced upon her by the parents of her pupils, who insisted upon the acquisition of something useful by their children. Like Myra Kelley's boy of the Ghetto, they believed the children had not time "to fool with their arms and legs." But with Montessori the sense training is the very essence of her work. She sees in it the biologico-psychological foundation of her system. If this position be maintained, Montessori would logically be regarded as a Simon-pure disciple of Seguin. Her apparatus is strikingly like that used for half a century in American schools for defectives. Even the "three periods" of Seguin find a place throughout her method. For example, she proceeds with the pupil in her training for touch:

(*a*) "Smooth, rough; smooth, rough."
(*b*) "What is this?" "Smooth." "What is this?" "Rough."
(*c*) "Give me the smooth." "Give me the rough."

Moreover, while such sense exercises are doubtlessly of great value in training defective children, the assumption of their usefulness in the education of normal children seems to be based upon a psychology, which, to say the least, has been rudely shaken. Apparently in this

Montessori adheres to the theory of "formal discipline." The exercises are intended to train *general* powers and discriminations. She maintains that: "the aim is not that the child shall know colors, forms and the different qualities of objects, but that he refine his senses through an exercise of attention, of comparison, of judgment; the exercises are true intellectual exercises." And this underlying theory is clearly to be perceived in the nature of the apparatus itself. The primal sense of touch is first exercised, as we have implied above, by passing the finger-tips of the children over various materials and pronouncing their nature as "rough" or "smooth"; and then by having the children name and select them by this description. Similarly, other general senses are developed—the "thermic," the "baric," the "stereognostic," the "visual," including color and form, and the "auditory."

(3) But, despite her own belief and wish, the feature of the Montessori system that has attracted most attention is its apparent success with the formal studies, especially in the facility and enthusiasm with which the children learn to write and in the beauty of their writing. The inventor of the method, of course, declares that this spectacular performance is of little account, save as a single link in the chain of sense development. All the tactile, dimensional, form and visual training, she holds, leads naturally to the writing coordinations. She has, however, made a most careful independent analysis of the writing process into its elements, and has invented three exercises by which the approach to the spontaneous development of the graphic language is directly accomplished. First, the "muscular mechanism to hold and use the instrument in writing" is developed by the child's filling in the outlines of a geometrical form that he has traced upon paper. During this period the child is also engaged in "exercises tending to establish the visual, muscular, and auditory image of the alphabetical signs" by means of sandpaper letters mounted on cardboard. The teacher shows the child how to follow the contour of a letter with his finger as if writing it and at the same time pronounce the sound (not the name) of the letter distinctly. Lastly, he is exercised in the composition of words by selecting unmounted cardboard letters from compartments in a set of boxes resembling a compositor's type-cases. "Now the child, it is true, *has never written*, but he has mastered all the acts necessary to writing." This is the secret of the much lauded "explosion into writing." The art is learned so unconsciously that the children begin it almost spontaneously and are writing before they realize it. This seems to be one decided achievement of Montessorianism, and if it can be applied to other languages not as phonetic as the Italian, it may be regarded as a permanent contribution to special method.

The Montessori methods in the other formal subjects—reading and arithmetic—are not as striking. Reading is generally acquired after writing through the names of familiar objects written on the blackboard or upon cards. The word is shown the child, and if he interprets the sounds correctly, the teacher has him repeat them more and more rapidly until the word as an entity, and not as a succession of sounds, dawns on his intelligence. After single words can be read with some facility, progress is made to short phrases and sentences. But there is nothing very novel about this method of securing interest in reading, and, when undertaken with English, where sounds are so capriciously spelt, it seems as if it could hardly be effective. Nor do the Montessori methods in arithmetic reveal anything very different in principle from the "table of units" of Pestalozzi, introduced into America nearly a century ago by Warren Colburn, or from the various objective methods in number work that have been so common ever since. The chief feature in the arithmetical methods of Montessori consists in acquiring the fundamental operations by means of rods of different lengths marked off into sections by coloring them alternately red and blue. This apparatus, known as "the long stair," was originally used for part of the visual training, and seems to have been conveniently at hand when Montessori found it necessary to start number work. After the child has learned to count the sections, the teacher selects a rod at random and asks for the next longer or shorter, or has the child build up all the rods until each result equals the longest. When the numbers from one to ten are fully understood in the concrete, the abstract conception is taught by placing the figures against the corresponding sections. Other exercises are similarly performed until the child has some command of elementary arithmetic.

The value of the Montessori system to modern educational theory and methods should now be fairly obvious. It is at least nominally based upon scientific experiment, and, while its biological statements can not always be accepted without modification, it is permeated with the scientific spirit that is animating modern education. Its emphasis upon individual liberty is most admirable, but the material for exercising this freedom is decidedly limited and social cooperation is somewhat neglected. The exercises in practical activities form a valuable, though not altogther original, feature, and the devices for acquiring writing are possibly a contribution. The importance of the sense training for normal children is probably not as great as Montessori supposes, and the psychological theory upon which it is based has been largely discredited. The devices for teaching reading and arithmetic contain no really new principle, and are not markedly superior to the methods practised for many years by progressive teachers. Clearly, however, while Montessori is neither the tremendous innovator nor "wonder-worker" she has been represented to be, her method is not merely the latest fad. Her indebtedness to the past and the comparative worth of her system are fairly evident to one acquainted with the history of education, but it would also seem that she is in harmony with modern progress and has made some contribution to educational practise. Just how large this contribution will be, we can not yet say. Montessori herself is still experimenting both with children of the age with which she began and with older pupils, and schools on a purely Montessori basis or in combination with Froebelian or other methods are springing up everywhere and are likely to obtain illuminating results. It is possible that a new method may yet arise for the lowest classes in our schools, which will combine the best characteristics of both the Froebelian and the Montessorian pedagogy. At any rate, the existence of either as a system, cult or propaganda should end, and both should be based upon and merged with the wider and more dynamic principles of modern educational practise. The Montessori method can be accounted a fad only when half-baked devotees treat it as something that has leaped full-panoplied from the divine head and prostrate themselves before it in blind worship.

# THE PROGRESS OF SCIENCE

## *RUTHERFORD ON THE CONSTITUTION OF MATTER*

THE most notable features of the annual meeting of the National Academy of Sciences held in Washington in the third week of April were two lectures by Sir Ernest Rutherford, the distinguished physicist of the University of Manchester. These are the first of a series of lectures, established by the children of William Ellery Hale, which are to treat problems of evolution from the atom to man. At the autumn meeting of the academy, stellar evolution will be reviewed by Dr. W. W. Campbell, director of the Lick Observatory. Sir Ernest's lectures, which were reported stenographically, will be printed in *Science* and ultimately in a book with the other lectures of the series. It is almost impossible to represent their contents by an abstract, but in view of the great interest and importance of the subject and the originality of some of the experiments and theories, it may be well to attempt to give an outline.

Sir Ernest began by reminding his audience that the idea that matter is composed of very minute discrete particles incapable of subdivision and therefore called atoms was familiar to the Greeks, atom in their language being equivalent to the indivisible. This idea was little developed until the beginning of the last century when Dalton first applied it to the chemical constitution of compounds showing that each separate element such as oxygen, iron, nitrogen, etc., always combines in a certain definite equivalent proportion. This is in fact the basal conception of modern chemistry and renders it possible to derive the composition of a substance from a chemical analysis. Chemistry thus lent exceedingly strong support to the hypothesis of the atomic constitution of matter, but no further advance in the subject was made till about the middle of the century when the so-called kinetic theory of gases was developed by Clausius and Maxwell. This theory accounts for the pressure and other properties of gases by supposing them constituted of single atoms, or of small groups of atoms united into molecules, moving with an amount of energy which is proportional to the temperature. The mathematical developments of this theory and the conclusions to be drawn from the formulæ have been verified in cases so very numerous that no one now or for a long time has doubted the essential correctness of the underlying hypothesis. In spite of the conviction that the kinetic theory was true, it was for long supposed that no actual demonstration of atomic or molecular structure could ever be reached. Of late years, however, the study of an almost forgotten phenomenon called the Brownian movement has led to actual demonstrations. Brown as long ago as 1827 observed that microscopic spores of plants suspended in a liquid were in constant motion. The smaller the particles the more actively they were displaced while their movements were thoroughly irregular, the spores passing one another in opposite directions or intersecting one another's paths without any general drift such as would have resulted from ordinary currents in the fluids due, for example, to differences of temperature. Of late years this Brownian movement has been studied with great precision by M. Perrin and others. It has been established that particles sufficiently small, say one ten-thousandth of an inch in diameter, are really displaced in a random manner by the vastly smaller invisible molecules of the fluid in which they are suspended, and that the movements of the molecules can be directly inferred from those of the Brownian particles.

Much more spectacular is the evidence afforded by the cathode rays developed in Crooke's tubes. In these tubes there is emitted from the cathode a stream of luminosity which has very remarkable properties especially that of being deflected by a magnet. This shows that the luminous ray is composed of material particles in motion and charged with electricity. Just to what extent these particles consist of ordinary matter and in how far merely of the electric charge is more or less problematical, but many physicists consider the moving entities as atoms of electricity and this also appears to be Sir Ernest Rutherford's view. These particles are now usually called electrons and they have been identified with the so-called beta rays emitted by radioactive products.

Radium results from the degeneration of uranium, though there are intermediate products, and radium itself likewise gives rise to a series of radioactive products differing from one another. In each of these cases of degeneration, the process is similar. Radium decomposes with the emission of two sorts of rays called the alpha rays and the beta rays. The alpha rays are neither more nor less than atoms of the gas helium, long since known to exist in the sum by its spectrum, and more recently detected in a uranium ore. The beta particles are identical with the electrons which form the cathode rays. The alpha particles are expelled from the radium at a tremendous velocity, but this is far exceeded by the velocity of the beta rays. Sir Ernest Rutherford and his colleagues in radiological investigation have succeeded not only in determining the identity of the alpha particles with helium, but also in establishing the relative size of the electrons and the atoms of helium. The mass of the beta particles is only about one seven-thousandth part the size of the helium atom, and most of the heating effect of radium is due to the energy of the larger alpha particles.

So far has the analysis of these products progressed, and so delicate is the apparatus devised for the study, that Rutherford and Geiger have actually succeeded in making either alpha or beta particles one by one give rise to electrical discharges and light in such a way that the number of either kind of particles emitted per second from a given mass of radioactive matter can be counted. The most efficient apparatus for this purpose is called the string electrometer, so designed as to give a record consisting of small notches on a continuous line. It is like the record of a chronograph and in fact the instrument may be considered as a chronograph. Of this record the notches produced by the alpha particles greatly exceed in depth those given by the beta particles, and thus the rate at which each is given off can be studied with the utmost accuracy on a permanent record.

In a popular description of this kind it is difficult to convey an idea of the extraordinary sensitiveness of the apparatus devised, and none at all of the genius which was requisite to its development, but perhaps enough has been said to show that the most carefully hidden secrets of the ultra-microscopic structure of matter are now subject to scrutiny, and that before long many of its features will be fairly well understood. Sir Ernest concluded his lecture by an illustration of the number of atoms contained in a cubic centimeter of helium. It was something like this. If one hundred million people were to undertake to count these atoms, each person enumerating four per second day and night, the tale would be complete in a couple of thousand years.

## *THE STRUCTURE OF THE ATOM*

Sir Ernest Rutherford's second lecture dealt with the problems of the structure of the atom and the bearings of recent researches on this subject. The lecture was most eloquent and left the audience in a condition of the greatest enthusiasm which they testified by rising to give a hearty vote of thanks to the lecturer.

The speaker began by enumerating some of the better known properties of radium and the radioactive products, such as the rate of decay of these substances, ranging from five thousand million years for the half period of uranium down to a few minutes for some of its descendants. He mentioned also the enormous energy of radioactive disintegration, showing that one pound of a radioactive product, if one could gather so much, has the explosive energy of ten million pounds of nitroglycerin. He dwelt also upon the experimental methods developed by Mr. P. T. R. Wilson by which the expulsion of alpha particles and beta particles can be made visible and even photographed. The first part of the path of the alpha particles is nearly straight, but as they lose energy, contact with molecules of other substances deflects them in a characteristic manner. The beta particles, on account of their greatly inferior mass, pursue very irregular courses.

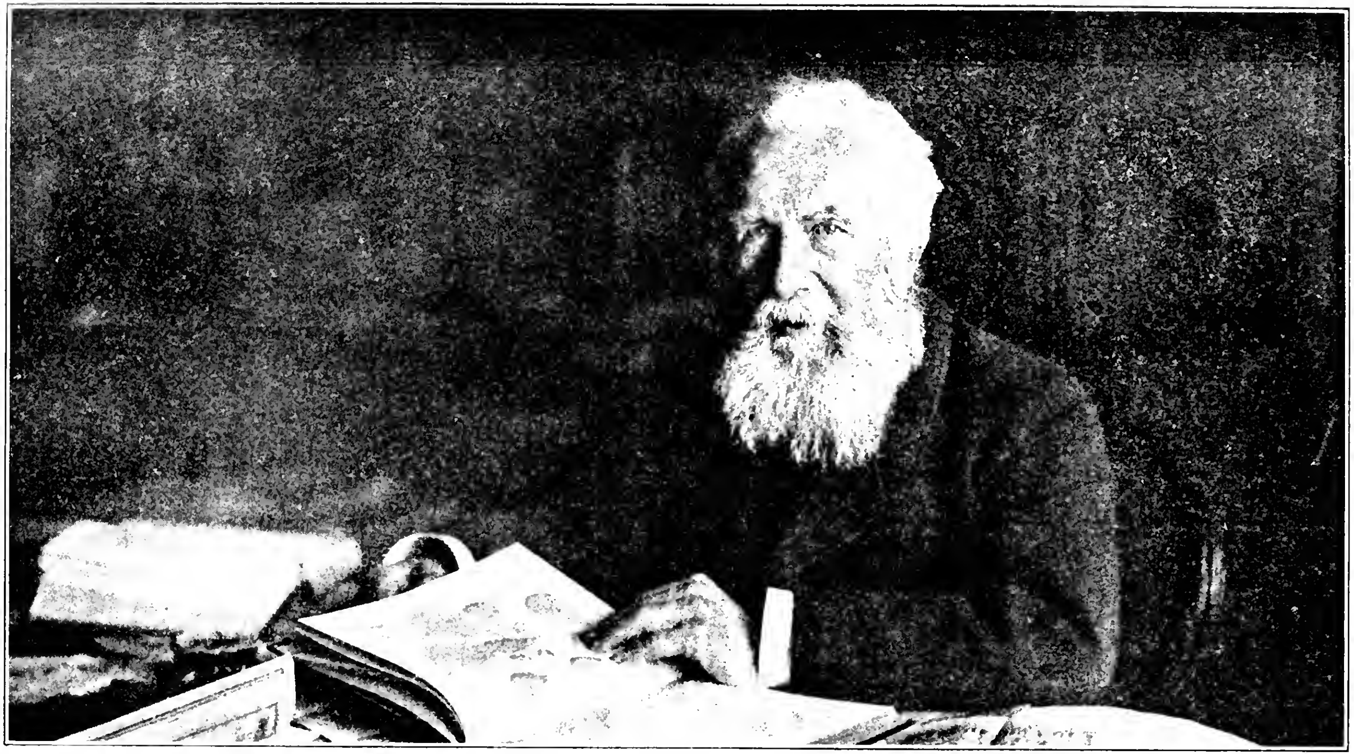
Less well known are the results obtained by Moseley on the interference spectra of X-rays produced by reflection from crystals, especially that of rock salt. These spectra are capable of being photographed and are vastly more simple and more regular than those obtained from visible light. These spectra evince a regularity among the elements which does not appear in the more familiar light spectra, and these regularities tend to elucidate the nature of the atom.

Lord Kelvin conceived an atom as composed of negative electrons included within a space charged with positive electricity holding the electrons together in a single body. This, however, appears to be inconsistent with the researches of Rutherford, who has developed a theory of nuclear atoms, according to which a central nucleus of extremely high potential is surrounded by negative electrons whose motion it controls. If so, the electrons are controlled by the nucleus very much as the planets are held to the solar system by gravitation, and indeed there appears strong reason to suppose that the force involved is really inversely proportional to the square of the distance as in the case of gravitation. From this point of view, the various elements are characterized by the number of electrons in the atom. Each electron carries a single negative charge, and the nucleus carries as many positive charges as there are electrons to be controlled. This theory of the atomic constitution explains the irregularity in the movement of alpha particles through a gas. When an alpha particle approaches a nucleus carrying a charge of millions of volts, it is sharply deflected and may appear even to rebound in the direction from which it came. Sir Ernest illustrated this by a fine experiment. Similarly, if there were a small hole drilled through the center of the earth, a ball dropped from the surface would go straight down and come straight back almost as if it had been infinitely elastic and rebounded from an impenetrable surface.

It is posible to determine the number of positive charges contained in each one of the elements from hydrogen to uranium, and it seems also that if the elements are appropriately arranged the charges increase by unit steps, so that hydrogen contains a single positive charge and uranium 92. This assumption corresponds to the actual elements with a small but very important exception. In the series of 92 possible charges, there are just three gaps, corresponding, presumably, to three unknown elements, and at the same time the relationship of these unknown elements to the known elements is made clear, so that the chemists have preliminary information to guide them in the search for the missing links. This is a wonderful advance on the periodic system of Mendelèef which has itself been fruitful in the discovery of elements.

## *THE SMALL COLLEGE AND ITS PRESIDENT*

THE writer of the article on "The Small College and its President" which appeared in the May number of



PROFESSSOR ERNST HAECKEL

The distinguished professor of zoology of the university at Jena whose eightieth birthday has been widely celebrated.

THE POPULAR SCIENCE MONTHLY writes to the editor to the effect that certain college teachers have professed to be able to find a personal application in the article in question. It has been charged that the picture of "our college" represents a certain trans-Mississipi institution, and that, concealed in the article, are various allusions to particular persons connected therewith. In order to correct this very serious misconception, the writer desires to make the following statement:

The institution referred to as "our college" is purely imaginary, or to speak more correctly, it is a composite picture intended to represent the typical American small college. It is doubtless true that the adherents of any particular college can find in the description details which fit their institution. Were this not the case the article would fail of its purpose as a composite portrait of all the colleges; but it will be found impossible to fit the entire description to any particular college, and it certainly was no particular college that the writer had in mind.

In his description of the size of the college, its faculty, the town in which it is located, its buildings, etc., the writer spoke entirely at random, and tried to picture what may fairly be regarded as average conditions. Since the resulting criticism has been brought to his attention, he has tried to fit the description to a particular college, but without success. He finds, however, that there are some three or four middle-west colleges which, if dismembered and patched together again in the proper pattern might make an institution which would fit pretty well for "our college." The description of the conditions in "our college" are, he believes, typical of the American small college, taking the best with the worst and averaging them, and he has arrived at this conclusion after wide reading in which the valuable reports of the Carnegie Foundation have not been neglected. The reference to the innocuous professor whose beautiful character compensated for the absence of scholarship was intended to represent a not unfamiliar type (at least in some of the older colleges) though the writer will plead guilty to being strongly reminded, while writing it, of the former incumbent of the chair of Latin in a certain eastern college. The incident of the professor who was criticized by one of the trustees for "inefficiency" because he staid at home and attended to his business, was related to the writer about ten years ago, and concerns a college which, so far as he is concerned, shall remain nameless. Suffice it to say that, so far as he has yet learned, nobody has suspected that the article refers in any way to that particular college. The writer does not even know the names of the principals in the case. These few instances will indicate the imaginary and composite character of "our college." It was represented as being on the Carnegie Foundation lest the foundation colleges, reading the article, point their finger at the outside institutions and say: "This is intended for *you!*" The evils incident to what the writer regards as a defective system of college organization affect the foundation colleges equally with the others, though the standard of the foundation colleges of course averages much higher. In fact these evils are not unknown in the universities, but there the problem is much complicated by other factors, and should for that reason be separately considered.

Least of all was it the intention to utter any criticism either on the president or trustees of the small college. The description of the president of "our college" is not a portrait, and the same is true of the trustees. Trustees, president and faculty, are alike victims of what the writer believes to be a defective system, and of the three the president is perhaps most to be pitied. Too often does he find himself in the position of being ground between the upper and the nether millstone. The trustees, as the writer knows them in more than one college, are high-minded, disinterested men, serving without recompense and often with a high degree of self-sacrifice. If anything was made clear in the article in question it was this: that any criticism either of president or trustees was directed not at individuals but at a *system* which demands impossible tasks of both.

## SCIENTIFIC ITEMS

WE regret to record the deaths of Dr. George William Hill, distinguished for his contributions to mathematical astronomy; of Dr. Charles Santiago Sanders Peirce, known for his work in logic and mathematics; of Professor Newton Horace Winchell, formerly state geologist of Minnesota, and of Professor Eduard Suess, the eminent Austrian geologist.

Dr. W. W. Keen, of Philadelphia, has been elected president of the Fifth International Congress of Surgeons to be held in Paris in 1917.—The Willard Gibbs medal of the Chicago section of the American Chemical Society has been presented to Dr. Ira Remsen, of the Johns Hopkins University.—Former students of Professor John Henry Comstock have raised a fund, to be known as the Comstock Memorial Library Fund, which is to be presented to Cornell University for a permanent memorial of Professor Comstock's forty years of distinguished service as instructor and professor of entomology.

The National Academy of Sciences at its annual meeting on April 22 presented its "medals for eminence in the application of science to the public welfare," to Colonel George Washington Goethals and Brigadier General William Crawford Gorgas. The presentation was made by Dr. William H. Welch, president of the academy, at a dinner held in honor of the retiring president, Dr. Ira Remsen, and the retiring home secretary, Dr. Arnold Hague.

Members of the National Academy of Sciences were elected at the annual meeting as follows: Ernest Merritt, physicist, Cornell University; Moses Gomberg, chemist, University of Michigan; Edward Curtis Franklin, chemist, Stanford University; Frederick Leslie Ransome, geologist, U. S. Geological Survey; Nathaniel Lord Britton; botanist, New York Botanical Garden; Henry Herbert Donaldson, neurologist, Wistar Institute of Anatomy; Herbert Spencer Jennings, zoologist, The Johns Hopkins University; Francis Gano Benedict, chemist, nutrition laboratory of the Carnegie Institution; Walter Bradford Cannon, physiologist, Harvard University; Jesse Walter Fewkes, ethnologist, Bureau of American Ethnology.

At its annual meeting in Philadelphia the American Philosophical Society elected to membership the following residents of the United States: Charles Greeley Abbot, Washington; James Wilson Bright, Baltimore; Bradley Moore Davis, Philadelphia; Thomas McCrae, Philadelphia; William Diller Matthew, New York; Alfred Goldsborough Mayer, Washington; Samuel Jones Meltzer, New York; John Campbell Merriam, Berkeley; Robert Andrews Millikan, Chicago; William Albert Noyes, Urbana; Stewart Paton, Princeton; Richard Mills Pearce, Philadelphia; Palmer Chamberlaine Ricketts, Troy; Harold A. Wilson, Houston; Frederick Eugene Wright, Washington. Foreign residents were elected as follows: Shibasaburo Kitasato, Tokyo; Heike Kamerlingh Onnes, Leyden; Vito Volterra, Rome.

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NAMES OF CONTRIBUTORS ARE PRINTED IN SMALL CAPITALS

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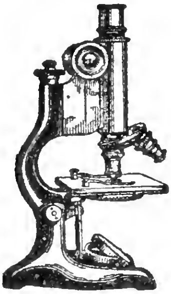

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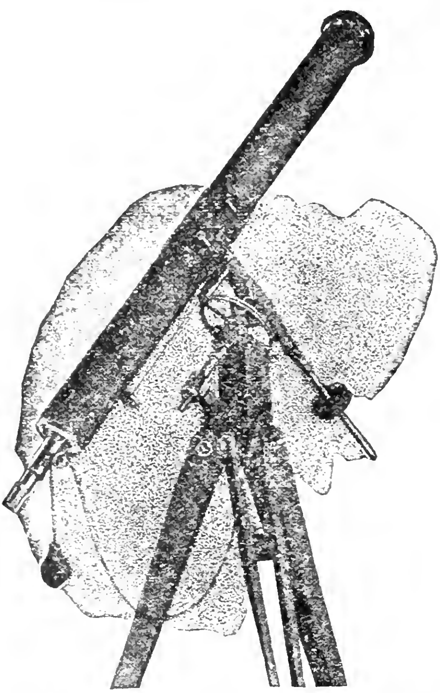

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But in deciding whether or no you are to buy *a general work of reference* you can apply, with some degree of certainty, the same test that you use in buying books in your *special field of study and research.* The contributors *in your field to the new Encyclopaedia Britannica are the world's greatest men in that field,* and you know them by name and by that reputation. From this you might infer that the whole book is written by equally great authorities, and that other departments of the Encyclopaedia Britannica were handled as efficiently as the one of which you can make a personal test. But let us not leave this merely to inference.

When this advertisement was being planned, a copy of the weekly SCIENCE containing the volume index was on the writer's desk. He was measuring the type page to see how many words he could get into the space. Before him was a list of the principal contributors to the Britannica in natural science; and these same names began catching his eye in the index to SCIENCE. Considerably more than half of the select list of Britannica contributors were mentioned in one way or another in the pages of SCIENCE during the last six months. During that time several had received high honors—medals of the Royal Society, the Royal Meteorological Society, the Liverpool School of Tropical Medicine, the Royal College of Physicians or some other honor on completing many years of life or of great service; others wrote important new books on subjects as diverse as *Organic Chemistry* and *The Geology of Soils,* reviewed in SCIENCE; or their lectures or addresses —on the Piltdown skull or on the value of the Natural Sciences—were reported in SCIENCE; or they wrote book reviews on *Mineral Deposits* or appreciations of Noguchi's work on infective diseases; and a few of them, including a great British physician and the director of the Cambridge University Astronomical Observatory, died during the period.

In other words if you looked over the list of contributors to the Britannica in *your* field of special study you would find them *the* authorities picked from the whole world. The same experiment tried by any of your colleagues, no matter how widely different his special field may be from yours, would result in the same way. Whether you argue from what has been said of the contributors to the Britannica whose names so constantly crop up in SCIENCE, or whether you take first *your* test of the men in your special field and then like tests made by *other experts* in the same way but in other branches of science—the result is the same. And not only in science, but in literature, art, history, or any other field, the authorities who contributed to the Britannica are *the* authorities known all over the world by the special students of each branch of knowledge.

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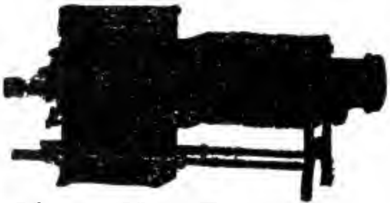

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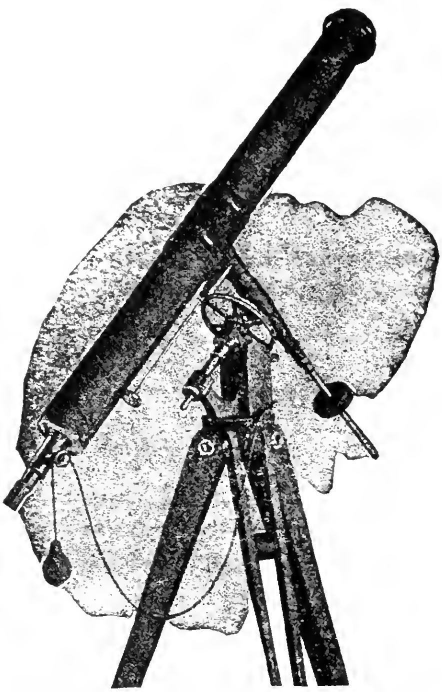

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A very moderate statement of the evils arising from the present system of college and university control. Professor ———. Yale University.

I am much in favor of the changes which you suggest; in fact, unless some changes are made soon, the entire university system as such will go to pieces. Professor ———. Columbia University.

I am in thorough sympathy with the plan of university control outlined by you. Professor ———. University of Pennsylvania.

Your proposals concerning the organization of universities are absolutely in line with my own hopes. Professor ———. Johns Hopkins University.

I think your scheme embodies most of the features of what it has seemed to me desirable to evolve towards. Professor ———. Princeton University.

The form of organization outlined by you seems to me to be an ideal one and I should be prepared to endorse every paragraph as you present it. Professor ———. Cornell University.

Your plan of university control meets my approval most decidedly. Professor ———. Massachusetts Institute of Technology.

I am heartily in sympathy with your article. Professor ———. Brown University.

Nothing could give me greater pleasure than to help you in every possible way to extend the influence of your ideas. Professor ———. Clark University.

It is quite obvious that we are floundering in the management of universities, and you are crusading in a good cause when you attempt to bring about conditions under which scholarship, expressed in instruction and production or research, may have a fuller or more normal development. Professor ———. Carnegie Institution of Washington.

I fully agree with your ideas concerning the reform of university control. Professor ———. Rockefeller Institute for Medical Research.

I am in cordial sympathy with the efforts you are making to bring about a betterment of university conditions. Professor ———. University of Maine.

Your plan of university control, as stated in an article received a short time back, appears to me to be very good. Professor ———. New Hampshire College.

The reform in university government, which you advocate is, I think, in the right direction. Professor ———. Worcester Polytechnic Institute.

I should heartily approve the plan set forth in your article as a desirable, but far distant, ideal. Professor ———. Amherst College.

I find myself in favor of most of the principles which you advocate in your article on university control. Professor ———. Dartmouth College.

What I especially like about this or any other similar scheme is that it involves the rescue of the professor from the position of a mere "hand" in the university machinery. Professor ———. Smith College.

I wholly approve of the principle and many of the details of the plan of university control proposed in your paper. Professor ———. Wellesley College.

Your suggested plan of university control seems to me admirable and calculated to obviate many of th evils of the present system, which are very grave. Professor ———. Vassar College.

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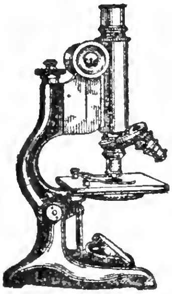

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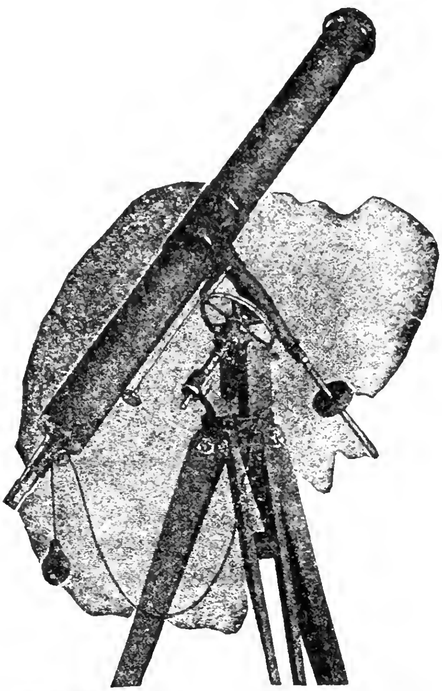

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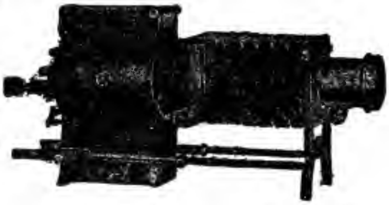

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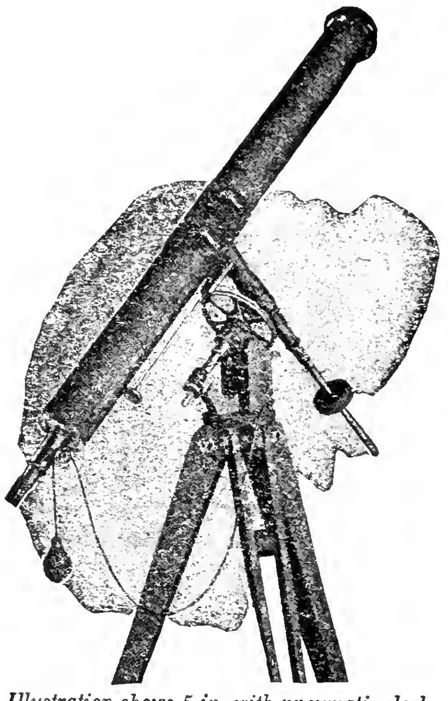

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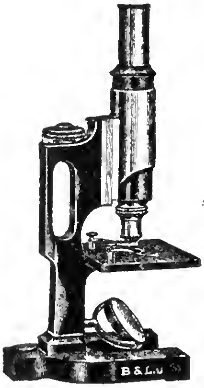


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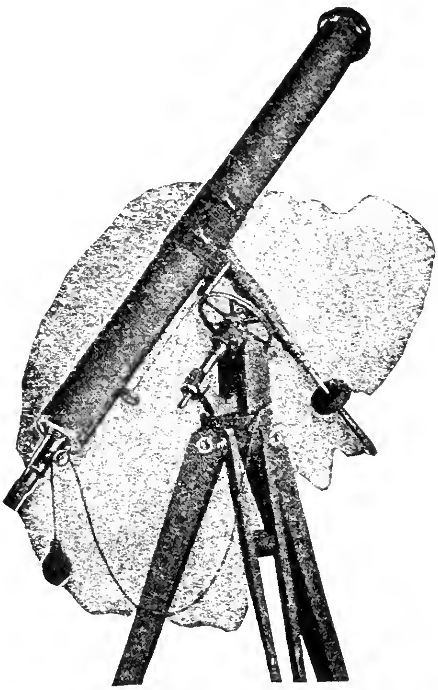

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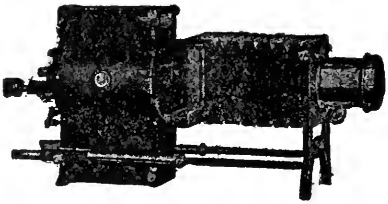

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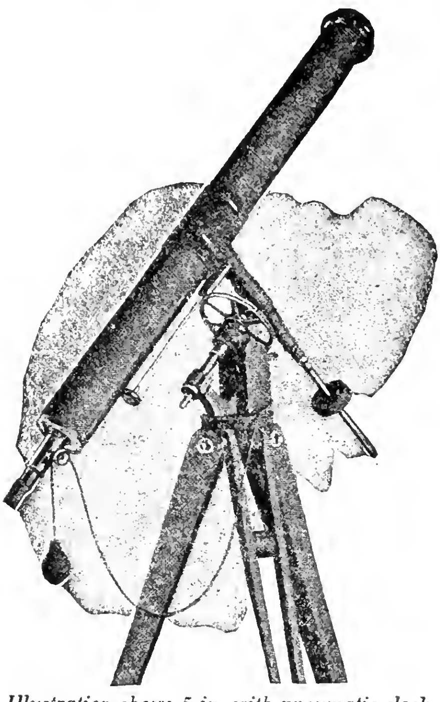

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